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JANUARY 1991

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REQUIREMENTS FOR SOLDERED ELECTRICAL CONNECTIONS

(NHB-5300.4(3A-2)) REQUIREMENTS
FOR SOLDERED ELECTRICAL CONNECTIONS
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NASA
NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION

Effective Date: JANUARY 1992

PREFACE

In order to maintain the high standards of the NASA soldering programs, this handbook:

Prescribes NASA's requirements for soldering reliable electrical connections.

Describes basic considerations necessary to ensure reliable soldering connections.

Establishes the supplier's responsibility to train and certify personnel.

Establishes the supplier's responsibility for documentation of those fabrication and inspection procedures to be used for NASA work, including supplier innovations, special processes, and changes in technology.

Provides workmanship standards.

NOTE: FOR THE PURPOSE OF THIS DOCUMENT, THE TERM SUPPLIER SHALL BE DEFINED AS IN-HOUSE NASA, NASA CONTRACTORS, AND SUBTIER CONTRACTORS.

NASA Installations shall:

Invoke the provisions of this handbook in procurements involving solder connections for space flight hardware and mission essential NASA equipment. Appendices A and B are requirements of this publication.

Amend, when timely and within cost constraints, existing contracts to invoke the requirements of this publication.

Assure that NASA suppliers invoke the requirements of this handbook in their subcontracts, purchase orders, and subtier suppliers.

Furnish copies of this publication in the quantities required to NASA contractors, subcontractors, and subtier suppliers.

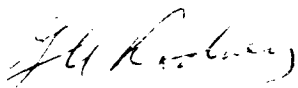
Utilize the provisions of this publication for in-house soldering operations and for training and certification of in-house personnel.

Questions concerning application of this publication to specific procurements shall be referred to the procuring NASA Installation or its designated representative.

Comments and suggestions for improvement of this handbook may be submitted using the form "NASA Handbook Improvement Proposal." A copy of this form is included at the end of the handbook.

This publication shall not be rewritten or reissued in any other form.

This revision cancels NHB 5300.4(3A-1), dated December 1976 and SP5002, Soldering Electrical Connections, A Handbook.


George A. Rodney
Associate Administrator for
Safety and Mission Quality

DISTRIBUTION:
SDL 1 (SIQ)

ORGANIZATION OF THE R&QA MANUAL

OVERALL COVERAGE

The Reliability and Quality Assurance Manual, referred to as the "R&QA Manual," is the overall generic title which identifies all NASA R&QA management publications published under the basic R&QA subject classification code. The publications are grouped by major subject breakdown and further divided into specific categories identified as Parts. These Parts (not a complete R&QA Manual) are published as individual R&QA publications.

- The following list shows the grouping of R&QA publications and is provided for reference purposes only:

Title	Number
Volume 1 - General Provisions	
Reliability Program Requirements for Aeronautical and Space System Contractors	NHB 5300.4(1A-1) Jan. 21, 1987
Quality Program Provisions for Aeronautical and Space System Contractors	NHB 5300.4(1B) Apr. 1, 1969
Inspection System Provisions for Aeronautical and Space System Materials, Parts, Components, and Services	NHB 5300.4(1C) July 1, 1971
Safety, Reliability, Maintainability & Quality Provisions for the Space Shuttle Program	NHB 5300.4(1D-2) Oct. 1, 1979
Maintainability Program Requirements for Space Systems	NHB 5300.4(1E) Mar. 10, 1987
Electrical, Electronic, and Electromechanical (EEE) Parts Management and Control Requirements for NASA Space Flight Programs	NHB 5300.4(1F) July 11, 1989

Volume 2 - Government Agency Provisions

Quality Assurance Provisions for Delegated Government Agencies	NHB 5300.4(2B-1) June 1, 1985
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Volume 3 - Standards

Requirements for Soldered Electrical Connections	NHB 5300.4(3A-2)
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Requirements for Interconnecting Cables, Harnesses, and Wiring	NHB 5300.4(3G) April 1, 1985
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Requirements for Crimping and Wire Wrap	NHB 5300.4(3H) May 1, 1984
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Requirements for Printed Wiring Boards	NHB 5300.4(3I) May 1, 1984
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Requirements for Conformal Coating and Staking of Printed Wiring Boards and Electronic Assemblies	NHB 5300.4(3J) April 1, 1985
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Design Requirements for Rigid Printed Wiring Boards and Assemblies	NHB 5300.4(3K) January 7, 1986
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DOCUMENT REFERENCING

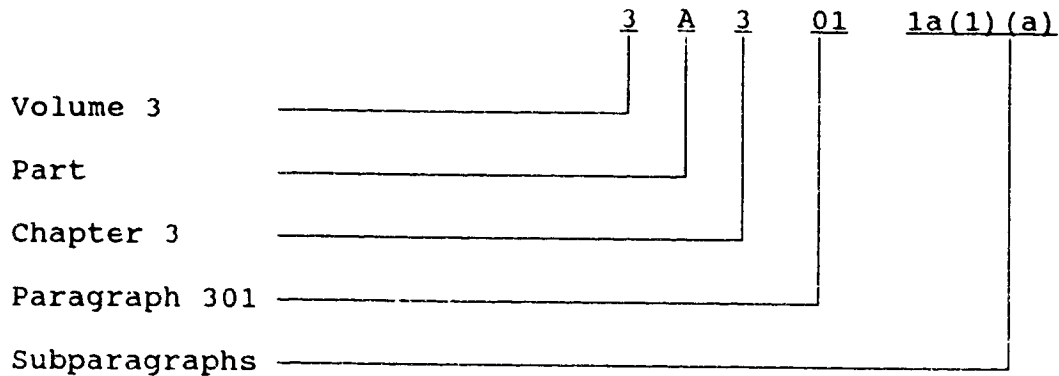
Each R&QA Manual Part is assigned its own identification number within the basic classification code. The numeric-alpha suffix within a parenthesis identifies the grouping of the publication, that is, the volume and part, such as NHB 5300.4(3A): this number indicates that this is the first "Standards" (Volume 3) publication to be issued.

When a part is revised, the suffix identification will be changed to indicate the revision number, such as NHB 5300.4(3A-1).

In referencing or requesting any R&QA publication, the complete specific NHB number must be used.

PARAGRAPH REFERENCING

1. **Within the R&QA Manual.** The following shows the paragraph numbering system applicable to all R&QA publications.



This numbering system provides for referencing any R&QA publication requirement (paragraph) in any other R&QA publication without the need for identifying the NHB number, title, the volume number, or part. However, when referencing a complete part within another R&QA publication, the specific NHB number must be used.

2. **In Other NASA Documents.** When it is necessary to reference an R&QA publication requirement (Paragraph) in any other NASA document, the specific NHB number and paragraph number must be used together as follows: "NHB 5300.4(3A-1), par. 3A303-2f(1)," or "paragraph 3A101-2b of NHB 5300.4(3A-2)."

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CHAPTER 1: BASIC PRINCIPLES

3A100 APPLICABILITY AND SCOPE

1. This publication is applicable to NASA programs involving solder connections for flight hardware, mission essential support equipment, and elements thereof.
2. This publication sets forth hand and wave soldering requirements for reliable electrical connections. The prime consideration is the physical integrity of solder connections.
3. Special requirements may exist which are not in conformance with the requirements of this publication. *Design documentation shall contain the detail for these requirements, and they will take precedence over conflicting portions of this publication when they are approved in writing by the procuring NASA Installation.*
4. This document does not define the soldering requirements for Surface Mounting Technology.

3A101 PRINCIPLES OF RELIABLE SOLDERING PROGRAMS

1. Reliable soldered connections result from: proper design; control of tools, materials, processes, and work environments; utilization of properly trained and skilled personnel; and careful workmanship.
2. The basic design concepts of NHB 5300.4(3K) should be used to ensure the reliable soldered connections required by NASA and to achieve the following requirements and design objectives:
 - a. Stress relief should be inherent in the design to avoid detrimental thermal and mechanical stresses on the solder connections.
 - b. Where stress relief is not used, a plated through hole (PTH) is mandatory.
 - c. Materials selection should provide minimal thermal expansion coefficient mismatch at the constraint points of the parts mounting configuration.
 - d. Parts mounting design requirements shall allow full visual or nondestructive inspection of all soldered connections.

- e. Proper storage and handling of parts (including electrostatic discharge sensitive devices), materials and conductors shall be required to prevent contamination and electrical or physical damage.
- f. Solder, flux, and heat must be applied in a manner that ensures alloying and forming of intermetallic bonding at the interface of the articles being joined, yet precludes overheating of the connection and part being installed.
- g. The soldered connection and adjacent areas should be promptly cleaned to remove all contaminants and flux residues.
- h. Only properly trained assembly, soldering, and inspection personnel shall be utilized.
- i. The establishment and use of manufacturing procedures, process controls, workmanship standards, and inspection accept/reject criteria.

3A102 GENERAL

- 1. NASA quality assurance personnel will advise and assist in the proper implementation of the provisions of this publication.
- 2. When related requirements or changes in requirements are specified, NASA quality assurance personnel will ensure that the authorized agent delegated to inspect at the supplier's site of fabrication has received full instructions, so that the work, including hardware, will be inspected to the actual contract requirements.
- 3. Unless parts are manufactured specifically to comply with contracts or subcontracts citing this publication, internal connections of parts (as parts are defined in Appendix A) are not subject to the requirements of this publication. The supplier shall assure that parts have suitable internal solder connections that will not unsolder or deteriorate when tinning is performed or external connections are made.
- 4. When the supplier proposes to use soldering processes, materials, or connections that differ from this publication, the supplier shall specify the details of the proposed differences in processes, fabrication, and inspection--including acceptance and rejection criteria--and provide a rationale for the change and appropriate test data. This documentation shall be

approved by the procuring NASA Installation prior to use.

5. If at any time, during any phase of the part mounting and/or the soldering operation, a condition should arise that the operator feels may damage or in any way affect the reliability of the hardware, the work should be halted until that condition is reviewed and resolved.
6. Material Safety Data sheets shall be available for solders, fluxes, solvents, and cleaners used in the area.

3A103 DOCUMENTATION

1. The supplier shall document the methods and procedures proposed to incorporate the requirements of this publication into the design, fabrication, and inspection of solder connections involved in the contract or purchase order.
2. Documents required herein, except as specified by paragraph 3A102-4, shall be submitted to the procuring NASA Installation or its designated representative as required by the contract or purchase order. Applicable supplier soldering program documents, or portions thereof, accepted on other NASA contracts shall be included to avoid duplication of effort.

3A104 RELATED DOCUMENTS

Applicable Specifications. Copies of the following applicable specifications required in connection with a specific procurement may be obtained from the procuring NASA Installation or as directed by the contracting officer. Unless otherwise specified, the issue and/or revision in effect on the date of invitation for bids or request for proposal shall apply. The following related documents form a part of this publication to the extent specified herein.

FEDERAL SPECIFICATIONS

O-M-232	"Methanol (Methyl Alcohol)"
QQ-S-571	"Solder, Tin Alloy: Lead Tin Alloy: and Lead Alloy"
O-T-620	"1,1,1 - Trichloroethane, Technical, Inhibited (Methyl Chloroform)"
TT-I-735	"Isopropyl Alcohol"

O-E-760 "Ethyl Alcohol (Ethanol) Denatured Alcohol;
Proprietary Solvents and Special Industrial
Solvents"

TT-B-848 "Butyl Alcohol; Secondary"

MILITARY SPECIFICATIONS

MIL-F-14256 "Flux, Soldering, Liquid (Rosin Base)"

MIL-C-81302 "Cleaning Compound, Solvent,
Trichlorotrifluoroethane"

MIL-T-81533 "Trichloroethane 1,1,1 (Methyl Chloroform)
Inhibited, Vapor Degreasing"

MIL-C-85447 "Cleaning Compounds, Electrical and
Electronic Components"

OTHER DOCUMENTS

ASTM-D-1007 Standard Specification for Secondary - Butyl
Alcohol

Industrial Ventilation Manual of Recommended Practices.
Published by American Conference of Governmental Industrial
Hygienists 6500 Gel, Bldg D-5, Cincinnati, Ohio 45211.

Occupational Safety and Health Administration, Title 29, CFR,
Part 1910 to 1919, Chapter XVII.

3A105 DEVIATION AND WAIVER REQUESTS

1. This publication requires:
 - a. Written approval from the cognizant NASA contracting officer for technical changes, deviations, or waivers initiated by the supplier.
 - b. All deviation and waiver requests shall be supported by objective evidence and data substantiating that quality and reliability will not be compromised.
2. The supplier is responsible for assuring that any departures from this publication are evaluated by, coordinated with, and submitted to the procuring NASA Installation.
3. For in-house NASA projects, this publication requires the written equivalent of deviation and waiver

requests, approved by the in-house NASA project management, to deviate from the provisions herein.

3A106 REWORK AND REPAIR

1. Rework is permissible unless excluded by provisions of the contract. All rework shall meet the requirements of this publication and design documentation.
2. Repair is not rework. Repair shall be made only in compliance with applicable contractual requirements and after authorization for each incident by the procuring NASA Installation. Repairs shall be accomplished using documented methods previously approved in writing by the procuring NASA Installation. For in-house NASA projects, repairs shall be authorized, in writing, for each incident by the appropriate project office and quality management.

3A107 DEFINITIONS

For the purpose of this publication, the definitions in Appendix A shall apply.

CHAPTER 2: TRAINING AND CERTIFICATION PROGRAM

3A200 GENERAL

1. The supplier is responsible for maintaining a documented training program that meets the requirements of this handbook.
2. The supplier shall assure that the electronics packaging design personnel are familiar with the requirements of this handbook, soldering techniques and other pertinent requirements of the contract. The supplier shall implement and document a training program which provides the necessary training of soldering and inspection personnel in parts mounting and connection requirements, soldering techniques, and use of equipment and procedures pertinent to their responsibilities in performance of the contract requirements. The supplier is responsible for certifying and maintaining the certification of each individual who solders, inspects or instructs.
3. Operators, inspectors, and instructors shall be qualified to fulfill all requirements of this handbook involved in their assigned tasks. Demonstration of proficiency and understanding of the requirements is a requisite for certification and recertification. Evidence of certification status shall be maintained in the work area.

3A201 VISION REQUIREMENTS

1. The supplier is responsible for ensuring that all personnel who perform soldering or inspect soldered connections meet the following vision test requirements as a prerequisite to certification and recertification. The vision requirements may be met with corrected vision (personal eyeglasses). The vision tests shall be administered by or under the direct supervision of a state licensed eye examiner using standard instruments and techniques. Results of the visual examinations shall be maintained and available for review.

2. The following are minimum vision requirements:
 - a. **Far Vision.** Snellen Chart 20/50.
 - b. **Near Vision.** Jaeger 1 at 14 inches, or reduced Snellen 20/20 or equivalent.
 - c. **Color Vision.** Ability to distinguish red, green, blue, and yellow colors as prescribed in Dvorine Charts, Ishihara Plates, or AO-HRR Tests.
 - d. **Binocularity.** Ability to demonstrate normal fusion (eye coordination) at 'near point' using standardized screening instruments such as the Keystone Visual Skills Series.

NOTE: A PRACTICAL TEST, USING COLOR CODED WIRES AND/OR COLOR CODED ELECTRICAL PARTS, AS APPLICABLE, IS ACCEPTABLE FOR COLOR VISION TESTING.

3A202 CERTIFICATION LEVELS

1. Level A NASA instructors are certified by the NASA Training and Certification Board. Level A NASA instructors have the authority to train Level B instructors, operators, and inspectors. Upon successful course completion, a certificate shall be issued.
2. Certification of Level B instructors shall be provided by the supplier based on successful completion of the training by a Level A NASA instructor. Level B instructors are authorized to train operators and inspectors employed at their organization and subtier contractors.
3. Certification of inspectors shall be provided by the supplier based on successful completion of the training by a Level A NASA instructor or Level B supplier instructor. An inspector is trained and certified to inspect for conformance with the requirements of this handbook.
4. Certification of operators shall be provided by the supplier based on successful completion of the training by a Level A NASA instructor or Level B supplier instructor. An operator is trained and certified to fabricate solder connections in conformance with the requirements of this handbook. When operators are certified to perform limited operations or processes, it shall be stated on the certification card.

3A203 TRAINING PROGRAM REQUIREMENTS

1. The supplier training program documentation shall be submitted to the procuring NASA Installation as directed by the contract. A NASA Generic Training Plan from the NASA Training Centers is available for use as a guideline.
2. The training program shall:
 - a. Identify the criteria for qualification and certification of Level B instructors, inspectors, and operators.
 - b. Document the methods and procedures proposed to fulfill the requirements of this handbook.
 - c. Utilize visual standards consisting of satisfactory work samples or visual aids that clearly illustrate the quality characteristics of soldered connections applicable to the contract.
 - d. Utilize applicable illustrations in this handbook, supplemented as necessary, for visual standards. Standards of unacceptable conditions may also be used for clarification or comparison.
 - e. Utilize appropriate work samples or visual aids for approved connections other than those illustrated herein.
 - f. Make applicable standards readily available.
3. Wave Soldering Process Training Requirements. The supplier is responsible for training and certifying the wave soldering process instructors, operators, and inspectors. In addition, instructors and inspectors must complete the training requirements of paragraphs 3A202-2 and 3A202-3 respectively.

3A204 DOCUMENTATION

1. The supplier training program documentation shall describe the training and certification program proposed to satisfy the requirements herein for the types of solder connections to be made. This documentation shall include the following, as applicable:

- a. Qualification(s) of instructors.
 - b. Procedures for training, including who will be trained and for what purpose, (i.e., operator, inspector).
 - c. Lesson plan(s) and/or student handbooks.
 - d. Hours of instruction.
 - e. Procedures for certification and recertification.
 - f. Procedures for recording training, recertification, and a method of identifying/recalling trained personnel.
 - g. Certification criteria.
- 2. Records of training and certification shall become part of the suppliers quality data and shall be retained for a minimum of 5 years.
 - 3. Evidence of certification status including limitations shall be available in the work area.

3A205 MAINTENANCE OF CERTIFICATION STATUS

- 1. Maintenance of certification for instructors, operators, and inspectors requires continuous proficiency.
- 2. Recertification of Level B instructors shall include the successful completion of re-training by a Level A NASA instructor. Recertification of operators and inspectors shall include successful completion of re-training by a Level A NASA instructor or a Level B supplier instructor.
- 3. Recertification shall be required when:
 - a. Proficiency requirements herein are not met.
 - (1) Instructors - proficiency unacceptable.
 - (2) Operators - unsatisfactory quality of articles fabricated.
 - (3) Inspectors - unsatisfactory quality of inspection.

- (4) Quality/quantitative data demonstrates a need for recertification.
 - b. New soldering or inspection techniques are approved that require different skills.
 - c. Certificate holder changes employment.
 - d. Work period interruption of greater than 6 months occurs.
 - e. Two years have elapsed since the last certification.
4. Certification shall be revoked when:
- a. Certificate holder fails recertification.
 - b. Certificate holder fails to meet visual acuity requirements of paragraph 3A201.
 - c. Employment is terminated.
 - d. Supplier training program fails to meet requirements set forth herein or set forth otherwise in the contract.

3A206 TRAINING RESOURCES

1. Training of Level B instructors is available at either the Goddard Space Flight Center (GSFC) or Jet Propulsion Laboratory (JPL). The NASA Generic Training Plan will be supplied to instructors at the time of course completion.
 - a. GSFC (301) 731-8628
 Training Center FAX (301) 731-8603
 Code 300.1
 Greenbelt, MD 20771
 - b. JPL (818) 354-4165
 Training Center FTS 792-4165
 MS83-205 FAX (818) 393-4382
 4800 Oak Grove Drive
 Pasadena, CA 91109
2. Suppliers may train operator or inspector personnel in-house for certification or recertification utilizing certified instructors and approved soldering programs, or arrange for this training at one of the NASA-conducted schools.

3. Reimbursable costs may be charged. Contact either training center for additional information.

CHAPTER 3: FACILITIES, TOOLS, AND MATERIALS

3A300 FACILITY CLEANLINESS

The area shall be maintained in a clean and orderly condition. Smoking, eating, and drinking in soldering areas and at individual work stations shall not be permitted. Materials unessential to the fabrication area are also prohibited at the work station.

3A301 ENVIRONMENTAL CONDITIONS

1. **Environment.** The temperature and humidity shall be monitored in the soldering area. They shall be maintained within the limits defined as the comfort zone in Figure 3-1.
2. **Special Environmental Requirements.** Parts or equipment being processed that require more stringent control of environmental conditions than those stated above shall have these requirements and controls identified and specified in the engineering documentation.

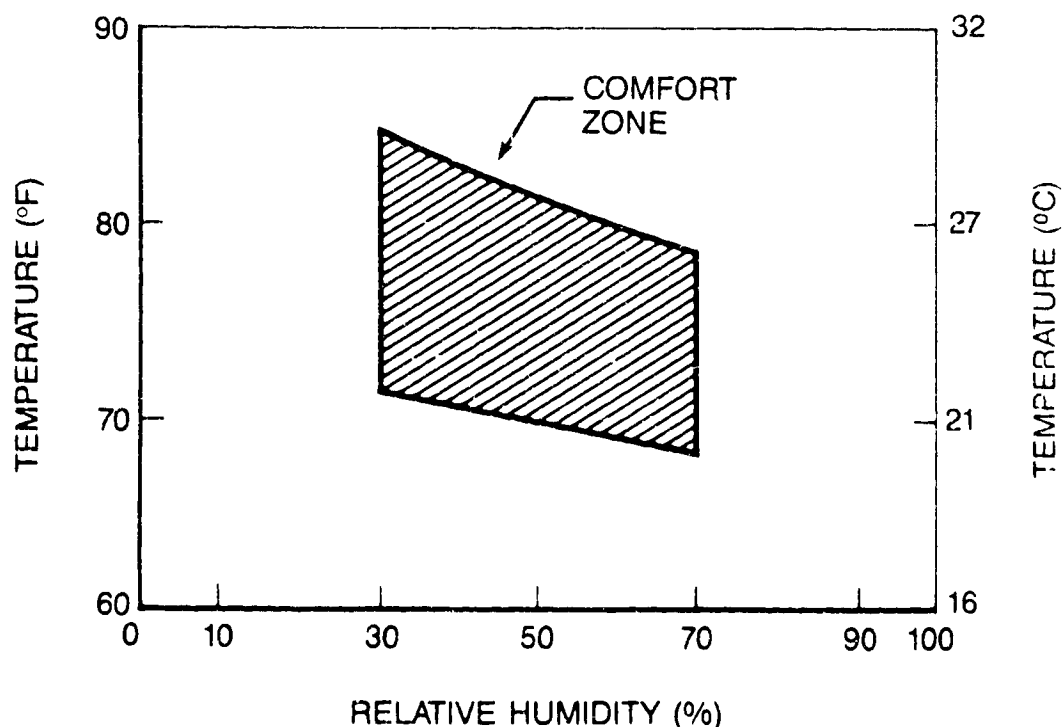


Figure 3-1. Comfort Zone Chart
Temperature versus Humidity Requirements

3. **Ventilation System.** Areas used for cleaning parts, and areas where toxic or volatile vapors are generated, shall have an adequate ventilation system for removing air contaminants. The ventilation system shall comply with the recommendations and guidelines of the Industrial Ventilation Manual of Recommended Practices and Occupational Safety and Health Administration (OSHA) requirements, 29 CFR Part 1910.1000 through 1910.1200.
4. **Field Operations.** In field operations where the required controlled environment conditions cannot be effectively achieved, special precautions shall be taken to maximize the quality of solder connections and minimize the effects of the uncontrolled environment on the operation being performed on the hardware.
5. **Lighting Requirements.** Light intensity shall be a minimum of 100 foot-candles (1077 Lm/M^2) on the surface being soldered or inspected. Supplemental lighting may be used to achieve the required lighting levels.

3A302 ELECTROSTATIC DISCHARGE REQUIREMENTS

Electrostatic discharge (ESD) requirements shall be defined by the procuring NASA Installation.

3A303 TOOL AND EQUIPMENT CONTROL

1. Each supplier shall:
 - a. Select tools to be used in soldering and in work preparation areas, appropriate to their intended function.
 - b. Clean and properly maintain all tools and equipment.
 - c. Examine all elements of tools, used in soldering, for physical damage.
 - d. Prohibit unauthorized, defective, or uncalibrated tools in the work area.
 - e. Document detailed operating procedures and maintenance schedules for tools and equipment requiring calibration or set ups. Maintain records of tool and equipment calibration and functional testing.
2. The supplier shall have a documented calibration system that controls the accuracy of tools and equipment.

- a. Measurement standards used for calibrating tools must be traceable to the National Institute of Standards and Technology. Calibration of tools shall be performed in an environment compatible with the environmental requirements of the tools.
- b. Calibration intervals shall be based on the type of tool and records of its calibration. Intervals may be shortened or lengthened on the basis of stability demonstrated over previous calibration periods.
- c. Procedures shall be generated and utilized for the calibration of all tooling stated herein. Procedures shall include, as a minimum, standards to be used, parameters to be measured, accuracy, tolerances, environmental factors, and steps in the calibration process. The procedures may be the manufacturer's specifications, if judged adequate, and need not therefore, be rewritten, but must be documented.
- d. Records shall be maintained that document the data for each tool calibration.
- e. Tools shall be labeled to indicate, as a minimum:
 - (1) Date of calibration.
 - (2) Calibration due date.
 - (3) Any limitation of use. If not practical to place the label directly on the tool, then the label shall be affixed to the tool container.
 - (4) The identification of the organization performing the calibration.
 - (5) A tool identification.
 - (6) Traceability on the tool to the container if the container contains the calibration label.
- f. Power tools used during the soldering process shall comply to the tool requirements herein and have a three-wire grounded power cord or be double insulated. The area making contact with the workpiece shall be grounded (e.g., solder iron tip). When measured from the workpiece contact point to ground, the resistance shall not exceed 2.0 ohms and the potential difference shall not

exceed 2 millivolts RMS using methods indicated in supplier's process documentation.

3. The supplier's process documentation for tool control is subject to review and approval by the procuring NASA Installation. Suppliers may elect to use tools not mentioned in this handbook provided the process documentation is reviewed and approved by the procuring NASA Installation.

3A304 SOLDERING TOOLS AND EQUIPMENT

1. **General.** Each supplier shall:
 - a. Select tools and equipment that provide a means of applying and controlling the amount of heat to the metals to be joined, that is compatible with their size, shape, and thermal conductivity. The equipment must be able to maintain soldering temperature at the connection throughout the soldering operation.
 - b. Prohibit the use of soldering guns.
2. **Resistance-Type Soldering.** Resistance-type soldering electrodes of tweezer or clamp design, with surfaces that contact the items to be soldered, shall be maintained parallel with each other and free of pits, burn marks, corrosion, and contamination.
3. **Conductive-Type Irons.** Soldering irons shall be of the temperature controlled type, controllable within $\pm 10^{\circ}\text{F}$ ($\pm 5.5^{\circ}\text{C}$) of the preselected idling temperature.

NOTE: THE RECOMMENDED TEMPERATURE FOR HAND SOLDERING IS $600^{\circ} \pm 35^{\circ}\text{F}$ ($315.5^{\circ} \pm 19.4^{\circ}\text{C}$) FOR SN60 AND SN63 SOLDER.

4. **Solder Pots.** Solder pots shall be capable of maintaining the solder temperature at $\pm 10^{\circ}\text{F}$ ($\pm 5.5^{\circ}\text{C}$) of the preselected temperature. Solder pots shall be grounded.
5. **Wave Soldering Equipment.** Requirements for wave soldering equipment can be found in Chapter 9.

6. **Supplemental Heat Sources.** When supplemental heat is applied by hot gases, radiant energy, or any other source for aiding the hand and wave soldering process, the equipment shall be set up, operated, and maintained by personnel using established and documented procedures, which are subject to review by the procuring NASA Installation.

CAUTION

HEAT SHALL NOT BE APPLIED TO A SOLDERED CONNECTION OR ADJACENT AREAS IN SUFFICIENT INTENSITY TO DEGRADE THE CONNECTION OR DAMAGE ADJACENT PARTS OR AREAS.

3A305 CONDUCTOR PREPARATION TOOLS

1. Conductor preparation tools shall be selected as follows:

Insulation strippers and lead bending tools shall not nick, ring, gouge, or scrape conductors or otherwise damage parts. In addition, they shall not contaminate conductors or hinder solder wetting.

2. Insulation stripping tools suitable for use include:

- a. **Mechanical Strippers.** Mechanical strippers utilized to remove insulation from stranded or solid conductor wires may be of the hand operated or automatic high volume machine type. Hand operated strippers shall be of a fixed die configuration. Automatic high volume machine strippers shall be of a type utilizing either fixed dies, dies adjustable to calibrated stops, or roller cutters adjustable to calibrated stops. Dies, whether adjustable or fixed, shall be properly maintained to assure consistently sharp and even cuts without damage to the wires or unstripped insulation.
- b. **Thermal Strippers.** Thermal strippers utilized to remove insulation from stranded and solid conductor wires shall be of a type that can provide the required regulated temperature for the insulation type. Temperature controls shall be sufficient to prevent damage to the wire or unstripped insulation.
- c. **Chemical Strippers.** Chemical solutions, pastes, and creams used to strip wires shall be suitable for removal of the insulation to be stripped and shall not cause degradation to the wire. In

addition, wires must be neutralized and cleaned of contaminants in accordance with manufacturer's recommended instructions.

NOTE: CHEMICAL STRIPPING MATERIALS AND METHODS REQUIRE PREAPPROVAL FROM PROCURING NASA INSTALLATION.

- d. **Thermal Solder Stripping.** Where applicable, thermal solder stripping of magnet wire may be performed by hot solder application in compliance with the manufacturer's recommendations.
 - e. **Fiberglass Stripping Wheel.** A device that utilizes fixed fiberglass stripping wheels may be used for magnet wire.
- 3. **Holding Devices.** Tools, fixtures, and materials used to hold or restrain conductors and parts shall be of a design that will not damage or deform the conductors, conductor insulation, or parts.
 - 4. **Bending Tools.** Tools used for conductor bending may be automatic or hand operated and shall be of a material that will not cut, nick, or otherwise damage solid or stranded conductors, or insulation during the bending operation. Bending tools shall be of a type that imparts no damage to the part bodies or seals. Smooth impression marks (base metal not exposed) resulting from bending tool holding forces shall not be cause for rejection.
 - a. **Automatic Lead Forming Devices.** Automatic lead forming devices are acceptable, provided the bend meets the mounting requirements herein.
 - b. **Clinching Tools.** Clinching tools shall not cause damage to printed wiring boards (PWB's), printed circuitry, and part leads or bodies.
 - 5. **Conductor Cutting Tools.** Tools used to cut part leads shall not cause damage to PWB's, printed circuitry, or part leads and bodies. Diagonal, side, or end flush cutting tools may be used to cut leads of parts that are not sensitive to mechanical shock. Shear type cutters should be used for cutting shock-sensitive part leads to prevent damage.
 - 6. **Antiwicking Tools.** Antiwicking tools shall be of a design which fits only a specific conductor gage size and shall be marked with that conductor gage size.
 - 7. **Cleaning Tools.** Cleaning tools shall be selected which minimize the generation of static charge. Typical cleaning tools include natural bristle brushes,

lint-free tissue, cotton swabs, etc. Steel-wire brushes, knives, erasers, emery cloth, sandpaper, and other devices that produce an abrasive action or cause contamination shall not be used.

3A306 THERMAL SHUNTS

Thermal shunts (also called heat sinks or heat dissipator clamps) shall be used to absorb heat from part leads as necessary to protect parts, insulating materials, and/or previously completed connections, from damage during soldering operations. Care shall be taken in the selection, application, and removal of thermal shunts to avoid damage to conductors, parts, insulation, or associated solder connections.

3A307 INSPECTION OPTICS

Visual inspection shall be performed using magnification aids conforming to the following:

1. For inspection of solder connections, magnification aids that permit simultaneous viewing with both eyes are preferred, but not required.
2. Magnification aids shall be capable of rendering true colors, proportional dimensions, and adequate resolution at the chosen magnification to perform the specified inspection.
3. The light source shall provide shadowless illumination of the area being viewed.
4. Utilize only glass optical elements.

3A308 IN-PROCESS STORAGE AND HANDLING

1. Each supplier performing soldering operations shall develop and implement requirements and procedures that control conditions to prevent damage to and degradation of parts and deliverable items. In particular, means shall be provided to prevent damage or contamination of printed wiring terminating areas, terminals, connectors, wire ends, or part leads during handling and storage. Containers shall be compatible with materials stored therein.
2. Contact with bare hands shall be avoided. However, when handling of metal surfaces that are to be soldered is unavoidable, clean, lint-free gloves or finger cots shall be used. Gloves and finger cots used shall not generate a static charge.
3. A supplier handling ESD sensitive parts and assemblies, shall implement an ESD Control Program. This program shall define the ESD control requirements for any activity that tests, inspects, services, manufactures, installs, packages, labels or otherwise processes ESD sensitive parts or assemblies. All personnel who handle static-sensitive parts and assemblies shall have been trained in the proper procedures and in the use of appropriate protective equipment to prevent ESD damage.

3A309 MATERIAL SOLDERABILITY

Solderability. All materials to be soldered shall be verified as solderable prior to use.

3A310 SOLDER

1. All solder used for tinning and solder connections shall conform to Federal specification QQ-S-571. Flux-cored solder shall be either composition SN60 or SN63 containing flux types R or RMA. For all soldering applications where adequate subsequent cleaning is not practical, only solder containing flux type R shall be used. Solid solders (no flux), for use in solder pots, shall be of the same composition in the material form Bar (B) or Ingot (I).

2. During soldering operations where connections are subsequently reheated, the use of high temperature solder alloy is permitted. Both the type of high temperature solder and the connection requiring the high temperature solder shall be specified on the engineering documentation.
3. **Variations.** The use of any other solder compositions and forms (including type RA flux) shall require the approval of the procuring NASA Installation.

3A311 LIQUID FLUX

1. **Types and Usage.** Process documentation shall describe the types of fluxes, where each is used, and the necessary precautions.
2. **Rosin Flux.** Rosin flux shall conform to MIL-F-14256, type R or RMA. For all fluxing applications where adequate subsequent cleaning is not practical, only type R flux shall be used. Liquid flux used with flux-cored solder shall be chemically compatible with the solder core flux and with the materials with which it will come in contact.
3. **Variations.** The use of any other flux compositions and forms (including type RA flux) shall require the approval of the procuring NASA Installation.

3A312 SOLVENTS AND CLEANERS

1. The solvents or aqueous cleaners used for removal of grease, oil, dirt, flux, and other debris, shall be selected for their ability to remove both ionic and nonionic contamination. The solvents or cleaners used shall not degrade the materials or parts being cleaned. A list of approved solvents and cleaners is provided in Table 3-1. Mixtures of the approved solvents may be used. Solvent containers shall be properly labeled. The use of any other solvents requires the approval of the procuring NASA Installation and shall be identified in the supplier's process documentation. Material Safety Data Sheets (MSDS) for solvents and cleaners shall be available for personnel review.
2. Solvents, in which a nitromethane stabilizer is blended with trichlorotrifluoroethane, conforming to either MIL-C-81302 or MIL-C-85447 (Type II) are also acceptable provided such mixtures are preblended by the supplier. THIS DOES NOT PRECLUDE THE ADDITION OF STABILIZERS BY THE USER TO REPLACE STABILIZERS LOST IN USE IN ORDER TO MAINTAIN THE SUPPLIER BLEND RATIO.

3. Trichlorotrifluoroethane blends, which include ketones or halocarbons, and other than chlorofluorocarbons defined in MIL-C-81302 or MIL-C-85447 (Type II) are unacceptable. Ketones may be used as a stabilizer, provided that the ketone level is less than 5 weight percent and the mixture is preblended by the supplier. THIS DOES NOT PRECLUDE THE ADDITION OF STABILIZERS BY THE USER TO REPLACE STABILIZERS LOST IN USE IN ORDER TO MAINTAIN THE SUPPLIER BLEND RATIO. Mixtures of trichlorotrifluoroethane and water shall not be used.

TABLE 3-1. Solvents and Cleaners

Solvent	Specification
Ethyl Alcohol	O-E-760, Types III, IV, or V
Isopropyl Alcohol	TT-I-735
Methyl Alcohol (see 3A312-4)	O-M-232, Grade A
Butyl Alcohol, Secondary (see 3A312-4)	ASTM-D-1007
1,1,1-Trichloroethane (see note 1)	MIL-T-81533 & O-T-620
Trichlorotrifluoroethane (see 3A312-2 and 3A312-3 and note 2)	MIL-C-81302 & MIL-C-85447, Type II

Cleaners

Cleaners	Specification/Note
Water	1 megohm-cm, minimum resistivity (See 3A312-5)
Detergent cleaners and saponifiers	See 3A312-6

NOTE 1: 1,1,1-TRICHLOROETHANE MAY ATTACK PLASTICS COMMONLY USED IN ELECTRONIC ASSEMBLIES--INCLUDING ACRYLICS, POLYCARBONATE, RUBBER, NEOPRENE, AND SILICONE. AVOID CONTAMINATION WITH WATER AS ACIDS MAY BE FORMED.

NOTE 2: CHLORINATED FLUOROCARBON COMPOUNDS (CFC's) HAVE BEEN SHOWN TO DEplete THE OZONE LAYER OF THE EARTH'S UPPER ATMOSPHERE.

INTERNATIONAL USAGE OF CFC'S IS BEING GRADUALLY REDUCED IN ACCORDANCE WITH THE "MONTREAL PROTOCOL ON SUBSTANCES THAT DEplete THE OZONE" UNDER THE AUSPICES OF THE UNITED NATIONS ENVIRONMENT PROGRAM (UNEP). THE EVENTUAL OBJECTIVE IS THE TOTAL ELIMINATION OF THESE SUBSTANCES.

CAUTION

CLEANERS AND SOLVENTS SHALL NOT BE USED IN ANY MANNER WHICH WILL CARRY TO OR DEPOSIT RESIDUE ON ELECTRICAL CONTACT SURFACES SUCH AS THOSE IN SWITCHES, POTENTIOMETERS, OR CONNECTORS.

4. Methyl alcohol and secondary butyl alcohol shall be used only when purchased as a constituent of an already blended solvent. Pure methyl alcohol or secondary butyl alcohol shall not be used alone as a solvent.
5. When deionized water is used, care shall be exercised to ensure that proper drying is accomplished immediately after its use.
6. Water based saponifier and detergent systems as per Table 3-1 shall require the approval of the procuring NASA Installation. Due to their relatively high surface tension, these cleaners are not recommended for use on PWB's with densely packed parts. Neither are they recommended for PWB's containing surface mount devices or other parts with very small spacing from the PWB surface. Incompletely removed residues are potentially corrosive.
7. Solvent and cleaning systems have the potential of removing marking information from parts. Appropriate marking permanency testing shall be performed as part of the evaluation procedure for any solvent or cleaning system.

CAUTION

SOLVENTS USED IN THE SOLDERING PROCESSES CAN BE HAZARDOUS AND VOLATILE. THESE MATERIALS SHALL BE USED IN ACCORDANCE WITH THE RECOMMENDATIONS AND GUIDELINES OF THE INDUSTRIAL VENTILATION MANUAL OF RECOMMENDED PRACTICES AND THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA), 29 CFR PART 1910.1000 THROUGH 1910.1200.

3A313 PERSONNEL PROTECTION

Personal-protective equipment shall be provided as appropriate to the work being performed. At a minimum, protective equipment shall include eye protection, gloves, and ventilation systems. Protective equipment shall comply with the requirements of OSHA, 29 CFR Part 1910.1000 through 1910.1200.

CHAPTER 4: PREPARATION FOR SOLDERING

3A400 PREPARATION OF SOLDERING TOOLS

1. Users shall check tools daily for proper condition, operation, performance, and cleanliness.
2. Prior to and periodically during use, the tip shall be checked for:
 - a. Proper insertion.
 - b. Tight attachment.
 - c. Cleanliness.
 - d. No oxidation scale between tip and heat element.
 - e. Proper grounding.
 - f. Proper tip size relative to the work involved.
 - g. Tip temperature.

3A401 PREPARATION OF CONDUCTORS

1. **Insulation Removal.** Stripping tools, used to remove conductor insulation, shall be of the correct size and in correct adjustment and/or calibration. The stripping tools, including chemical strippers, shall be in compliance with paragraph 3A305-2.
2. **Damage to Insulation.** After insulation removal, the remaining conductor insulation shall not exhibit any damage such as nicks, cuts, crushing, or charring. Conductors with damaged insulation shall not be used. Scuffing from mechanical stripping or slight discoloration from thermal stripping is acceptable.
3. **Damage to Conductors.** After removal of the conductor insulation, the conductor shall not be nicked, cut, or scraped to the point that base metal is exposed. Part leads and other conductors that have been reduced in the cross-section area shall not be used.

4. **Wire Lay.** The lay of wire strands shall be restored as nearly as possible to the original lay if disturbed. The conductor shall be cleaned following restoration to the original lay.
5. **Tinning of Conductors.** The portion of stranded or solid conductors or part leads that will eventually become a part of the finished solder connection shall be tinned with solder and cleaned prior to attachment. Immersion of conductors in a solder bath shall not exceed 5 seconds. Liquid flux may be used. The flux shall be applied so that it does not flow under the insulation except for traces carried by wicking. Precautions shall be taken when removing flux with a cleaning solvent to prevent excess solvent from flowing under the conductor insulation.
 - a. Hot tinning of solid conductors and part leads shall not extend closer than 0.020 inch (0.51 mm) to part bodies, end seals or insulation unless the part configuration and mounting configuration dictate it. If closer tinning is required, the part body, end seals, or insulation shall be inspected for damage after tinning, and the results recorded (see also paragraph 3A102-3).
 - b. Acceptable methods of tinning include using a solder pot or hand tinning with a solder iron. The use of other tinning processes requires the approval of the procuring NASA Installation and shall be identified in the supplier's process documentation.
 - c. Gold plating on all surfaces, which become a part of finished solder connections, shall be removed by two or more successive tinning operations (solder pot or iron), or by other processes demonstrated to have equivalent effectiveness.

CAUTION

THE CONTACT TIME BETWEEN GOLD PLATINGS AND MOLTEN SOLDER SHALL BE SUFFICIENT TO REMOVE ALL GOLD FROM THE CONDUCTOR. THIN RESIDUAL BANDS OF GOLD-TIN INTERMETALLIC CAN SEVERELY EMBRITTLE CONNECTIONS.

- d. Tinning solder pots shall be analyzed on an established schedule, based on usage, to ensure that they meet the requirements of

copper does not exceed 0.3 percent. Records of the analysis shall be kept. The solder pot may be dumped on an established schedule, based on usage, in lieu of analysis. When the solder produces a dull, frosty, or granular appearance on the work, the pot shall be immediately removed from use.

e. To maintain the proper purity of solder, the following procedures shall be adhered to during soldering:

- (1) Before the start of soldering operations, dross shall be removed from the solder bath surface.
- (2) Dross shall be periodically removed from the solder bath to assure that dross does not contact the items being soldered. Automatic or manual methods for removing dross are acceptable.

TABLE 4-1. Solder Contaminant Levels

Maximum Allowable Percent by Weight of Contaminant

Contaminant	Percent Allowed
Copper (Cu) - - - - -	0.25
Gold (Au)	0.20
Cadmium (Cd) - - - - -	0.005
Zinc (Zn)	0.005
Aluminum (Al) - - - - -	0.006
Antimony (Sb)	0.5
Iron (Fe) - - - - -	0.02
Arsenic (As)	0.03
Bismuth (Bi) - - - - -	0.25
Silver (Ag)	0.10
Nickel (Ni) - - - - -	0.01

f. Solder pots used for tinning operations should be maintained at required temperatures and monitored, as a minimum, before and after each tinning operation or 8-hour period of pot operation.

6. **Conductor Tinning Product Control.** Conductor tinning personnel shall ensure that the tinned surfaces exhibit at least 95 percent coverage. Wire strands shall be distinguishable.

7. **Rework of Tinned Conductors.** Rework shall be performed by repeating the tinning step defined in paragraph 3A401-5. Conductors that still exhibit unacceptable tinning coverage after re-tinning shall be rejected and processed through the suppliers nonconformance system.

3A402 PREPARATION OF PRINTED WIRING BOARDS, TERMINALS, AND SOLDER CUPS

1. Termination areas shall have been "tinned" with hot-coated tin-lead solder or hot reflowed, electrodeposited, tin-lead solder prior to the mounting of parts. Final solder terminations shall not be made to any PWB or solder cup that has not had the gold removed from the termination area.
2. Terminals and solder cups shall be examined for damage and cleaned prior to the attachment of conductors. Terminals and solder cups shall not be modified to accommodate improper conductor sizes.
3. The PWB's shall be cleaned and demoisturized within 8 hours of their initial exposure to soldering temperatures. The PWB's may be stored for longer periods of time in a controlled moisture-free atmosphere. Demoisturizing may be accomplished by an oven bake at 200°F (93°C) $\pm 10^\circ\text{F}$ ($\pm 5.5^\circ\text{C}$) for a minimum of 4 hours for a printed wiring assembly (PWA) or 2 hours for a bare PWB, or by a vacuum bake at a lower temperature. The time in and out of the oven or chamber shall be recorded.

CHAPTER 5: PARTS MOUNTING

3A500 GENERAL

Parts, terminals, and conductors shall be mounted and supported as prescribed herein. Dimensions provided in this chapter are for accept and/or reject criteria only. (See NHB 5300.4(3K) for design controlled dimension requirements.) These requirements apply to assemblies designed to operate within temperature limits from minus 55°C to plus 100°C (-67°F to 212°F). More extreme temperatures or other unusual environmental applications will require special design measures to provide necessary environmental survival capability. Such measures shall be detailed in the appropriate engineering documentation. Engineering documentation shall prescribe which alternative approach is selected, as well as staking compounds and conformal coating requirements. They shall also detail any special mounting arrangements or design requirements not fully covered herein.

1. **Stress Relief.** Stress relief shall be incorporated, wherever possible, into all leads and conductors terminating in solder connections, to provide freedom of movement of part leads or conductors between points of constraint. Leads shall not be temporarily constrained against spring-back force during solder solidification so that the joint is subject to residual stress. Examples of stress relief are shown in figures throughout this chapter.
2. **Part Positioning.** Parts shall be positioned in compliance with the engineering documentation and mounted in accordance with the requirements specified herein.
 - a. Parts shall be mounted so that terminations of other parts are not obscured. When this is not possible, interim assembly inspection shall occur to verify that the obscured solder joints meet the requirements herein.
 - b. Parts having conductive cases mounted over printed conductors or which are in close proximity with other conductive materials shall be separated by transparent insulation of suitable thickness. Insulation shall be accomplished so that part identification markings remain visible and legible.

3. **Visibility of Markings.** Where possible, parts shall be mounted in such a manner that markings pertaining to value, part type, etc., are visible. For parts marked in such a way that some of the marking will be hidden regardless of the orientation of the part, the following shall be the order of precedence for which markings shall be visible:
 - a. Polarity.
 - b. Traceability Code (if applicable).
 - c. Piece part value and type.
4. **Interference spacing.** Parts shall be mounted such that they do not overhang the edge of a PWB, terminal panel, or chassis member, unless otherwise specified by the engineering documentation.
5. **Glass Encased Parts.** Glass encased parts, such as diodes, thermistors or resistors, shall be covered with transparent resilient sleeving or other approved material when epoxy material is used for staking, conformal coating, or encapsulating or where damage from other sources is likely. The epoxy material shall not be applied directly to glass.

CAUTION
WHEN USING HEAT SHRINKABLE SLEEVING, EXTREME CARE SHOULD
BE TAKEN TO PREVENT PART DAMAGE DUE TO EXCESSIVE HEAT OR
SHRINKAGE OF THE SLEEVING.

6. **Hookup Wire.** Hookup wire, solid or stranded, shall be supported by a means other than the solder connections or conformal coating if wire length exceeds 1 inch. Attachment to a surface by staking with resin is adequate support.
7. **Lead Bending and Cutting**
 - a. During bending or cutting, part leads shall be supported on the body side to minimize axial stress and avoid damage to seals or internal bonds. The distance from the bend to the end seal shall be approximately equal at each end of the part. The minimum distance from the part body or seal to the start of the bend in a part lead shall be 2 lead diameters for round leads and 0.020 inch (0.51 mm) for ribbon leads. The stress

relief bend radius shall not be less than the lead diameter or ribbon thickness. The direction of the bend should not cause the identification markings on the mounted part to be obscured. Where the lead is welded (as on a tantalum capacitor) the minimum distance is measured from the weld.

- b. Part leads shall be formed so that they may be installed into the holes in the PWB without excessive deformation that can stress the part body or end seals.
- c. All leads should be tinned and formed before mounting the part.

NOTE: WHERE POSSIBLE, PART LEADS THAT ARE SUBJECT TO STRESS CORROSION CRACKING (e.g., KOVAR LEADS), SHALL BE PREFORMED AND TRIMMED PRIOR TO TINNING.

- d. Whether formed manually or by machine, part leads shall not be mounted if they show evidence of nicks or deformations. Smooth impression marks (base metal not exposed) resulting from tool holding forces shall not be cause for rejection.
 - e. Tempered leads (sometimes referred to as pins) shall not be bent nor formed for mounting purposes since body seals and connections internal to the part may be damaged. Tempered leads or leads with a diameter of 0.05 inch (1.27 mm) or more shall not be cut with diagonal cutters or other tools that impart shock to connections internal to the part.
- 8. **Coated Parts.** Parts shall be mounted so that the insulating coating meniscus applied by the manufacturer on the leads does not enter the mounting hole or soldered connection.
 - 9. **Splices.** Broken or damaged conductors, part leads or printed wiring conductors shall not be spliced.
 - 10. **Location.** Part bodies shall not be in contact with soldered terminations.

3A501 MOUNTING OF TERMINALS

- 1. **General.** Use of terminals shall generally be restricted to situations where parts are expected

other compelling design requirements for their use.

- a. Terminals shall not be used as the interface connections in non-PTH's. Swaging of terminals shall be performed in a way that does not damage the PWB.
 - b. After swaging or flaring, the rolled area or flange shall be free of circumferential splits or cracks, but may have a maximum of three radial splits or cracks provided that the splits or cracks are separated by at least 90° and do not extend beyond the coiled or flared area of the terminal (Figure 5-1).
2. Swage type terminals in non-PTH's, designated to have the terminal shoulder soldered to the printed wiring conductor, shall be secured to the PWB by a roll swage (Figure 5-2).
 3. PWB designs calling for soldering of the swaged end of the terminal to the printed wiring conductor on a single sided PWB shall have the terminal secured with a V-funnel swage (refer to Figure 5-3).
 4. Swage type terminals that are mounted in a PTH shall be secured to the PWB by an elliptical funnel swage to permit complete filling of the PTH with solder (Figure 5-4). Terminals shall be swaged such that they can be rotated under finger force.

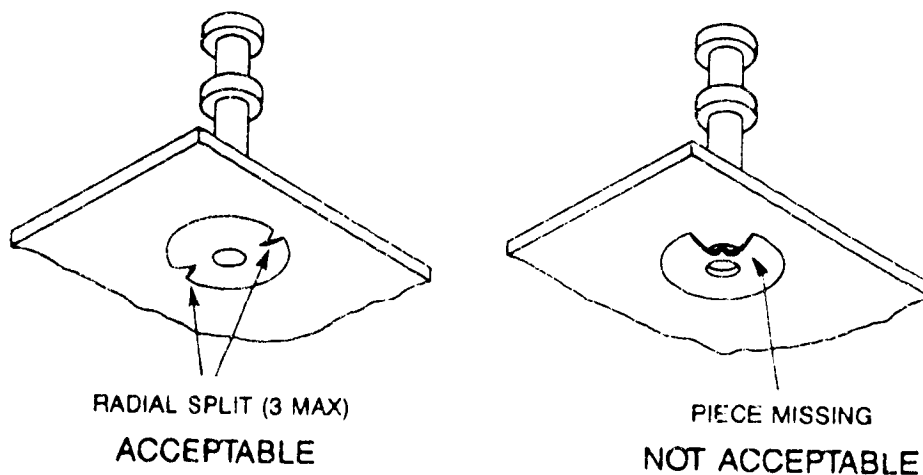


Figure 5-1. Terminal Damage

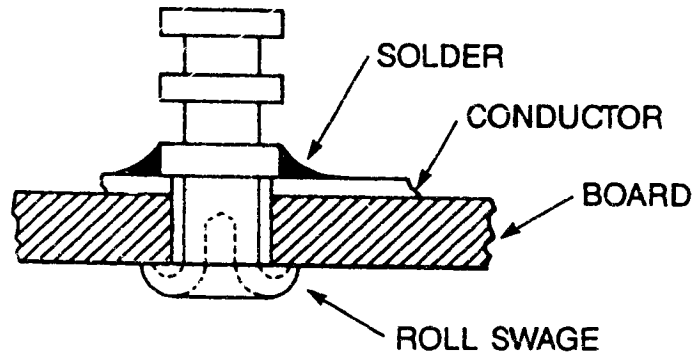


Figure 5-2. Roll Flange Terminal

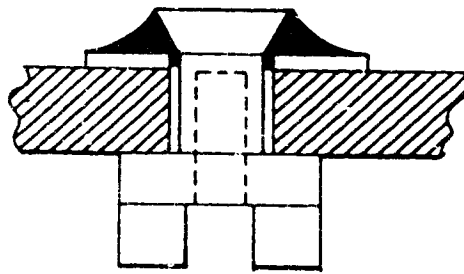


Figure 5-3. V-Funnel Type Swage

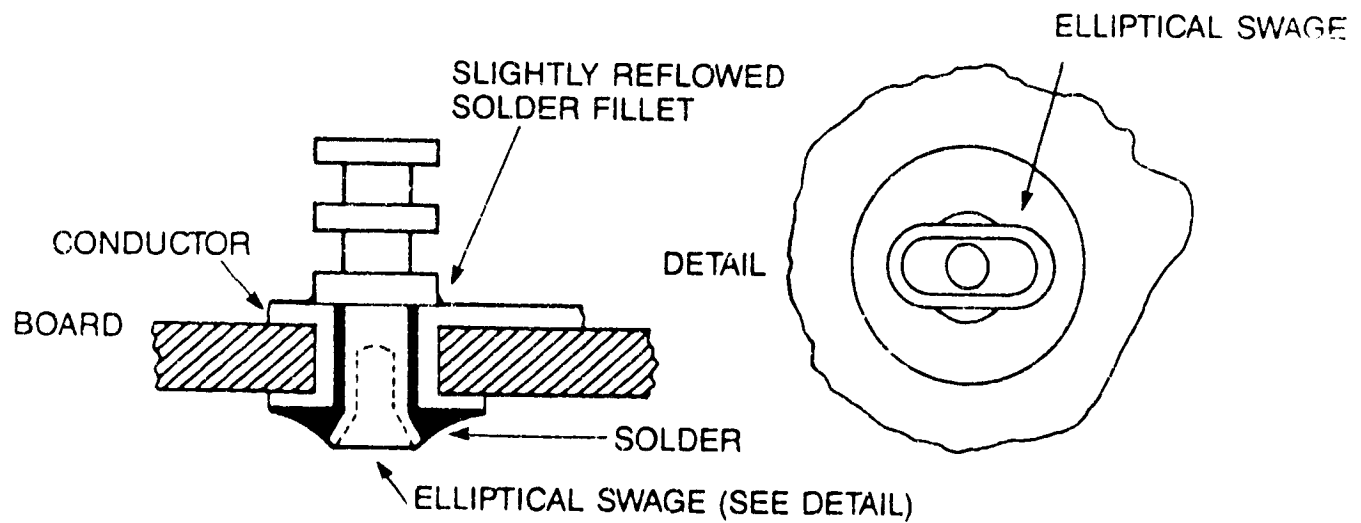


Figure 5-4. Elliptical Type Swage

3A502 MOUNTING OF PARTS TO TERMINALS

1. **Parallel Mounting.** Parts shall be mounted parallel to and in contact with their mounting surface. Slight angularity is permissible.
2. **Lead Lengths.** The length of leads between parts and terminals shall be approximately equal at both ends, except when special part shapes require staggering.
3. **Stress Relief.** Where parts are mounted between bifurcated terminals, without lead wrap, it is not mandatory that the part leads have stress relief bends. Where parts are mounted between other terminal types, it is mandatory to put a stress relief bend in at least one lead (Figure 5-5).

CAUTION

CARE SHALL BE EXERCISED TO ASSURE THAT SWAGED SOLDER CONNECTIONS ARE NOT MECHANICALLY STRESSED DURING PART MOUNTING OPERATIONS.

4. **Wrapping and Routing.** Degrees of wrap and routing are specified in Chapter 6.

SR = STRESS RELIEF BEND
CP = CONSTRAINT POINT

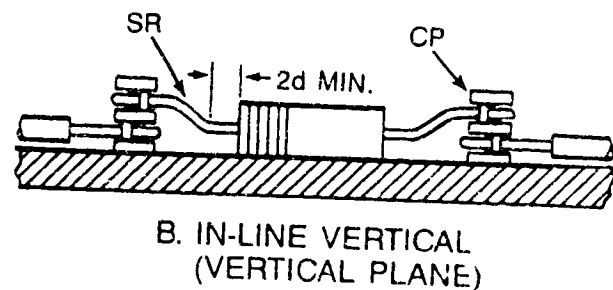
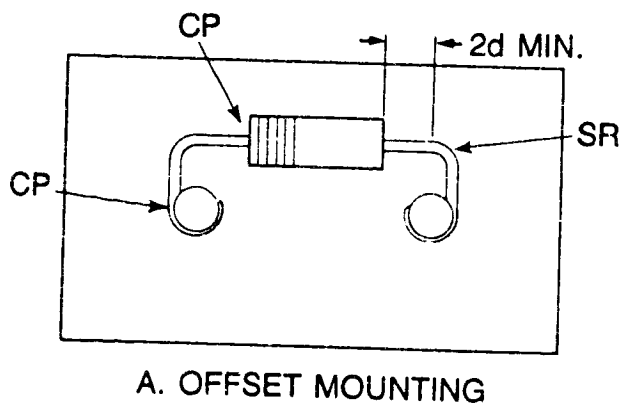


Figure 5-5. Stress Relief Examples

3A503 MOUNTING OF PARTS TO PWB's

1. **Parts Mounted To PWB's.** All terminating surfaces shall be solder tinned prior to soldering. Solder terminations shall be visible for inspection after soldering. In the cases where visual inspection cannot be accomplished, a nondestructive method of inspection shall be performed (e.g., X-ray and fiberscope). The nondestructive method of inspection to be used shall be documented and approved by the procuring NASA Installation prior to use. Recommended terminations and mounting techniques are shown throughout this chapter.
2. **Axial Lead Mounting.** Axial leaded parts shall be mounted as follows:
 - a. **Horizontal Mount.** Parts intended for horizontal mounting shall be parallel to and in contact with the mounting surface (see Figure 5-6). Slight angularity is permissible. When parts will be bonded, slight spacing will be acceptable.

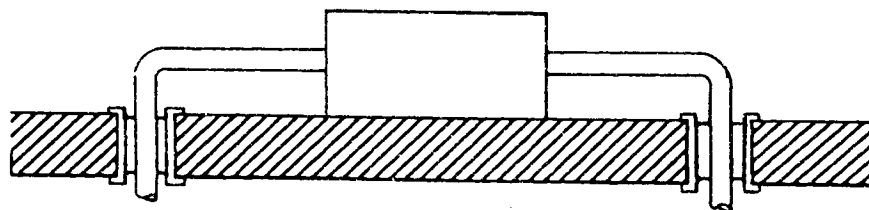


Figure 5-6. Horizontal Mount

b. Vertical Mount

- (1) **Plated Through Hole.** The end of the part body must be mounted with at least 0.020 inch (0.51 mm) to a maximum of 0.050 inches (1.27 mm) clearance above the PWB surface or as specified on engineering documentation. The end of the part is defined to include any extensions such as coating meniscus, solder seal, or weld bead (see Figure 5-7A).
- (2) **Nonplated Through Hole.** The end of the part body may be mounted flush with the PWB surface and shall be terminated with an off-the-pad-lap solder joint. The part shall be staked on the part side of the PWB. The opposite lead shall have two approximate right angle bends (see Figure 5-7B).

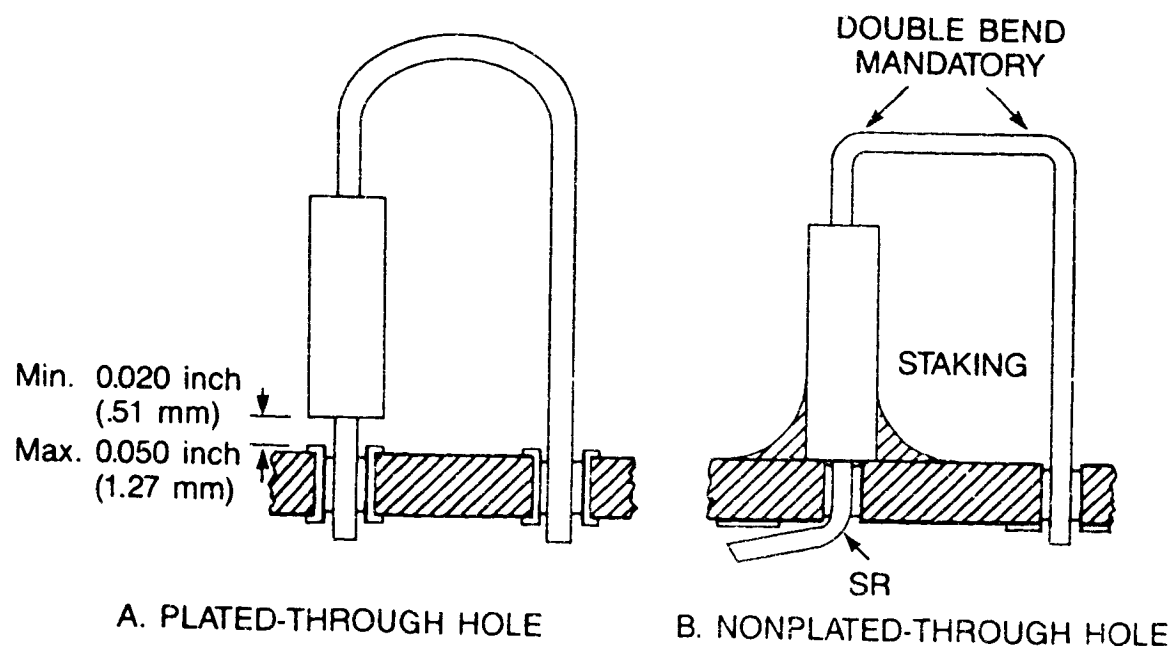
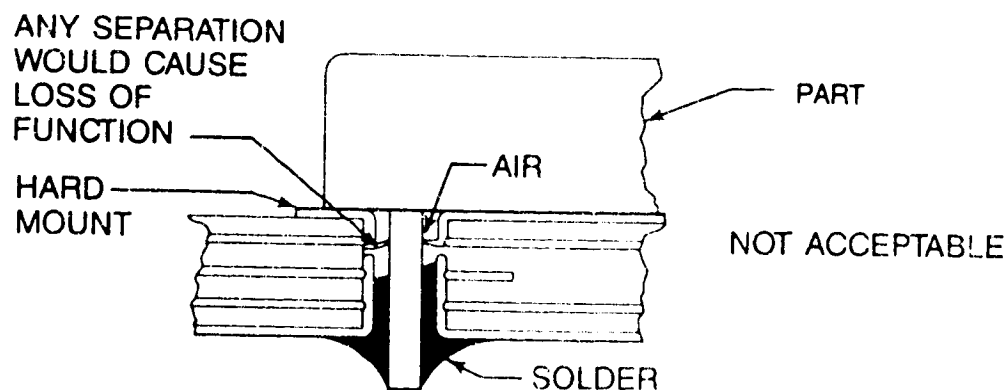


Figure 5-7. Vertical Mount

3. **Hole Obstruction.** Parts shall be mounted such that they do not obstruct solder flow onto the topside termination areas of PTH's (Figure 5-8).



NOTE: DURING SOLDERING OPERATIONS, SOLDER FILL ENDS WHEN THE PRESSURE OF THE ENTRAPPED AIR EQUALS THE PRESSURE OF THE MOLTEN SOLDER.

Figure 5-8. Hole Obstruction

4. **Parts with Leads Terminating on Opposite Sides.** Stress relief shall be provided in the part lead

between the part body and solder terminations (Figure 5-9). The lead may be terminated by clinch, straight-through, or lap configuration.

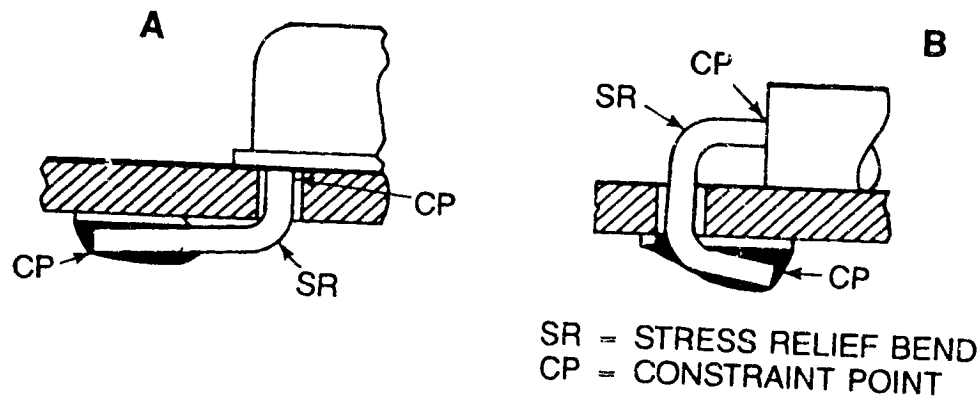


Figure 5-9. Stress Relieve Part Termination

5. **Parts with Leads Terminating on the Same Side.** Stress relief shall be provided by forming the part leads at a bend angle to the PWB of not more than 95° nor less than 45° (Figure 5-10).

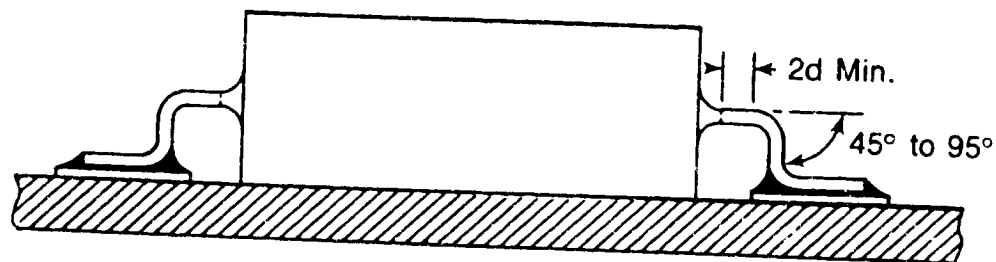


Figure 5-10. Bend Angle

6. **Conductors Terminating on Both Sides.** Stress relief shall always be provided in the part lead between the part body and solder termination. When a conductor is used to interconnect opposite sides of a PWB, stress relief or a PTH shall be provided (Figure 5-11).

□ = CONSTRAINT POINT
 { = STRESS RELIEF

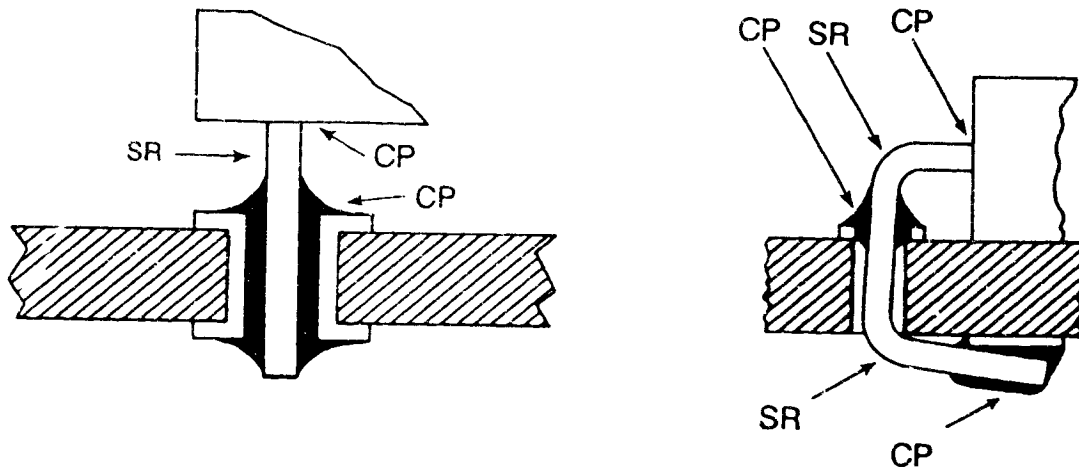


Figure 5-11. Conductors Terminating on Both Sides

3A504 LEAD TERMINATIONS, PRINTED WIRING BOARDS

1. **Part Lead Terminations.** Part leads shall be of the lap, clinched, or straight-through configuration as defined by the design documentation and shall be terminated in accordance with paragraphs 3A504-1a through 3A504-1c. No more than one item, whether conductor or part lead, shall be inserted in any one hole.
 - a. **Lapped Terminations.** Lapped terminations consist of both round and flat ribbon leads. It is preferred that leads be seated in contact with the termination area for the full length of the foot. Separation between the foot of the lead and the surface of the termination area shall not exceed 0.010 inches (0.25 mm) (see Figure 5-12).

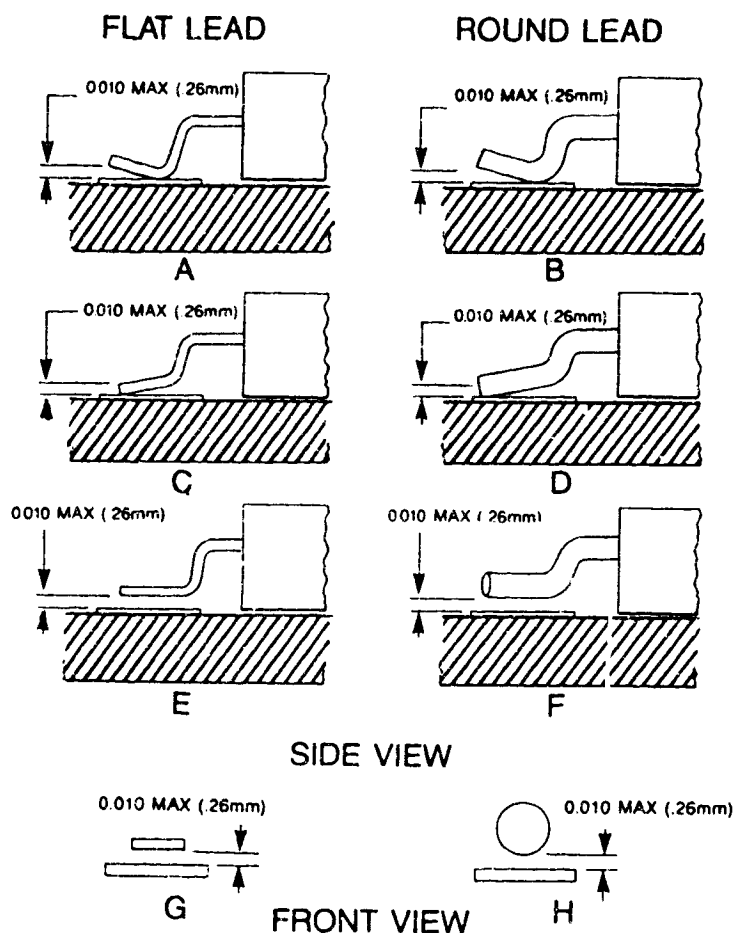


Figure 5-12. Lapped Lead Height Above Board

- (1) **Lapped Round Leads.** The round lead shall overlap the solder pad a minimum of 3.5 times the lead diameter to a maximum of 5.5 times the lead diameter, but in no case shall the length be less than 0.050 inch (1.27 mm). The cut-off end of the lead shall be no closer than 1/2 the lead diameter to the edge of the solder pad. Only that portion of the lead extending to the part body or to another soldered connection shall be beyond the solder pad (Figure 5-13). A heel fillet is mandatory.

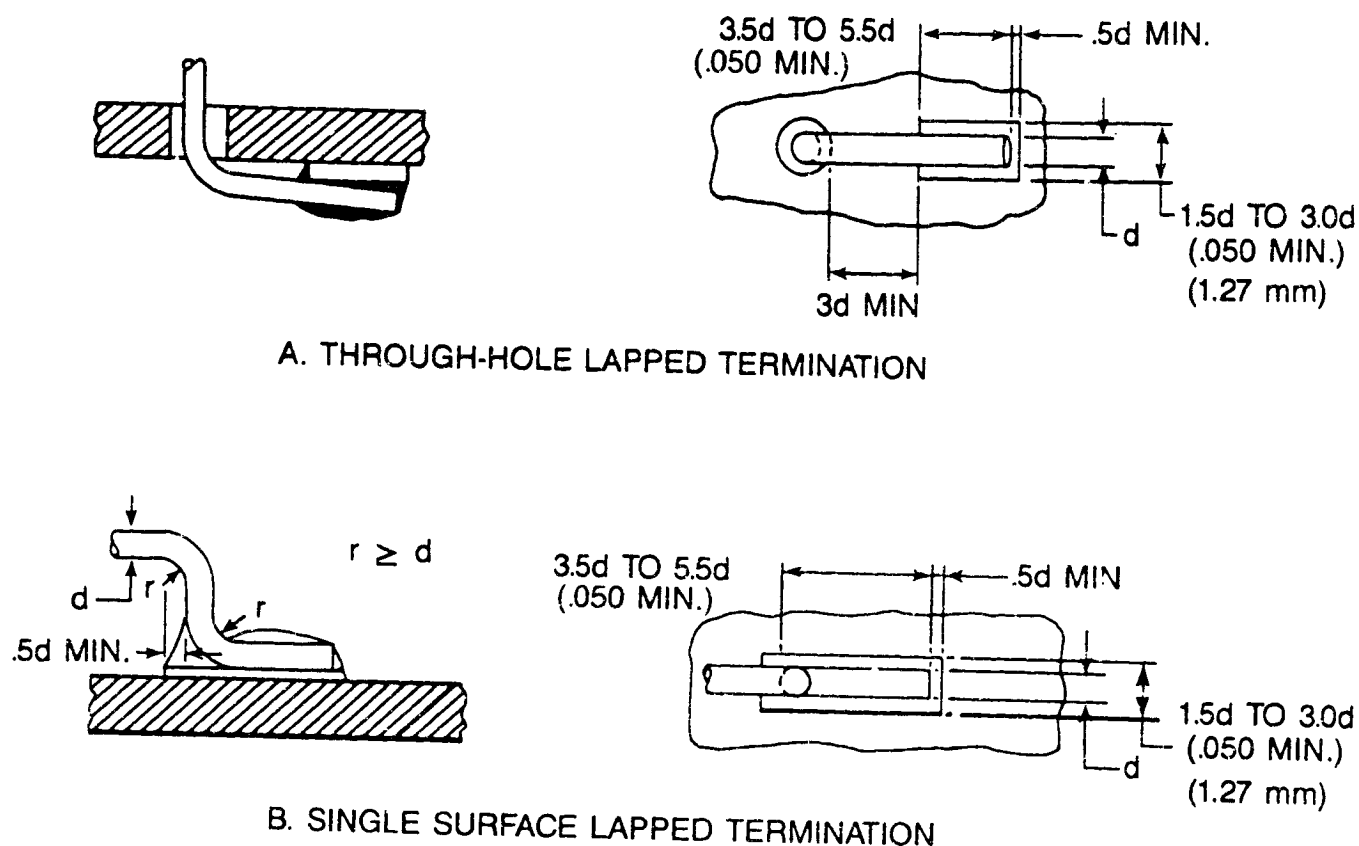
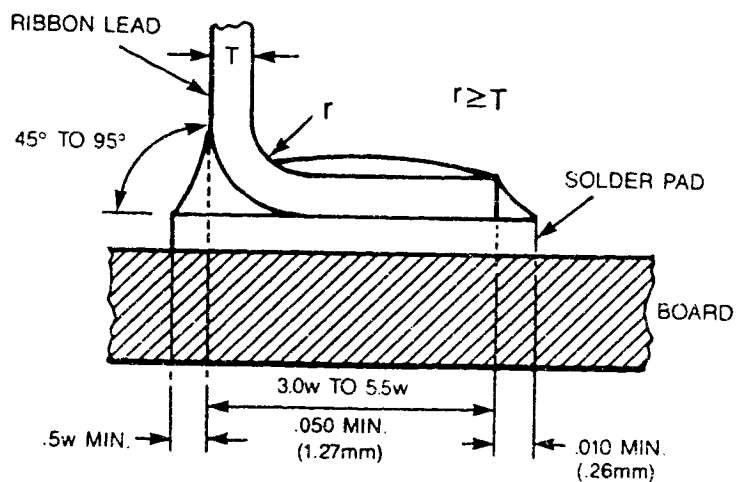
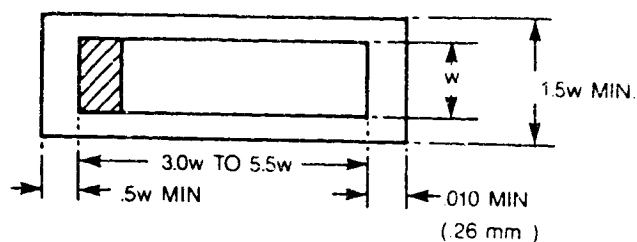
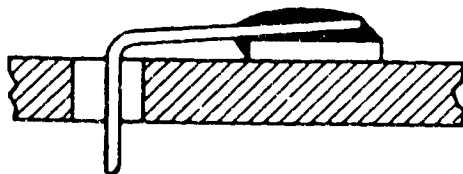
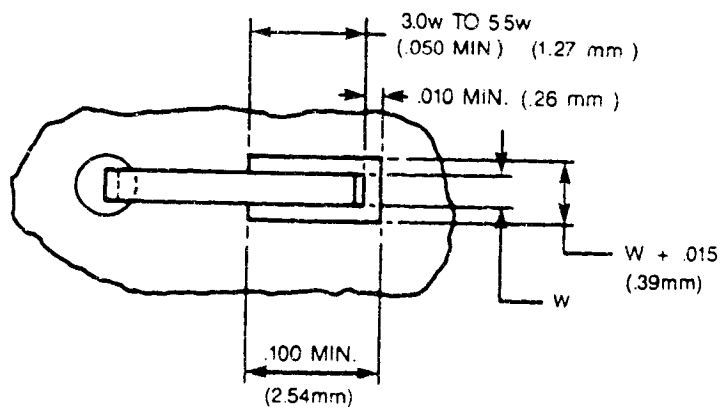


Figure 5-13. Lapped Round Termination

- (2) **Lapped Ribbon Leads.** The ribbon lead shall overlap the solder pad a minimum of 3 lead widths to a maximum of 5.5 lead widths. Only that portion of the lead extending to the part body or to another soldered connection shall be beyond the pad. The cut-off end of the lead shall be a minimum of 0.010 inch (0.25 mm) from the end of the pad. One edge of the lead may be flush with the edge of the solder pad. There shall be sufficient area around two of the three lead edges to accommodate solder filleting (see Figure 5-14). In instances where ribbon leads are less than 0.020 inch (0.51 mm) in width, ribbon overlap shall be no less than 0.050 inch (1.27 mm). A heel fillet is mandatory.



RIBBON LEAD, SINGLE SURFACE LAPPED TERMINATION



RIBBON LEAD, THROUGH HOLE LAPPED TERMINATION

Figure 5-14. Lapped Ribbon Leads

- b. **Clinched Lead Terminations.** The length of the clinched portion of conductors and part leads shall be at least $1/2$ the largest dimension of the solder pad or 0.031 inch (0.78 mm), whichever length is greater. The lead shall be bent in the direction of the longest dimension of the solder pad. However, if the pad dimensions are not sufficient, the lead shall be bent in the direction of the printed wire path (Figure 5-15). There shall be sufficient solder pad area extending beyond the sides of the lead to accommodate solder filleting. Fully clinched leads are defined as leads bent between 75° and 90° from a vertical line perpendicular to the PWB (Figure 5-16). Nonbendable leads shall not be clinched.

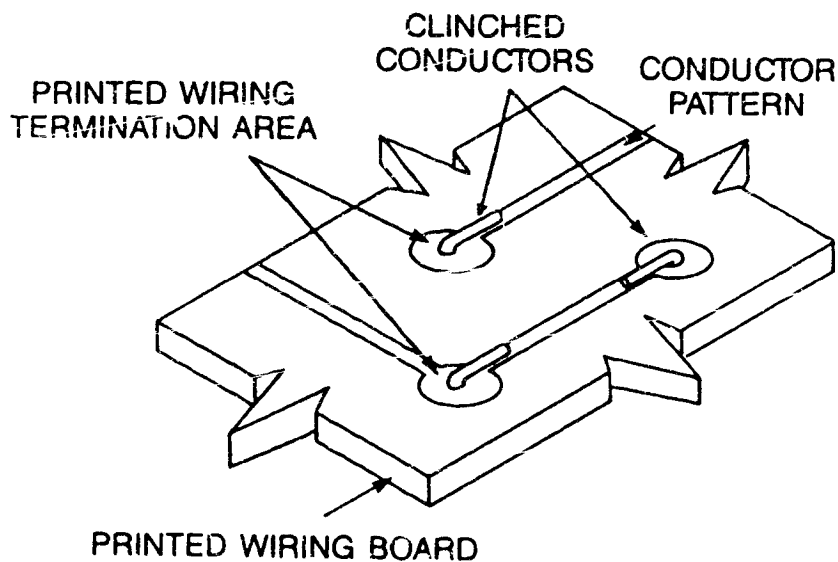


Figure 5-15. Clinched Termination

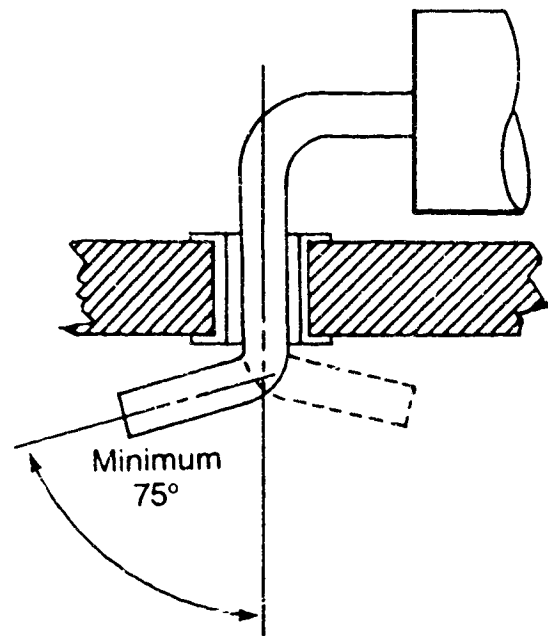
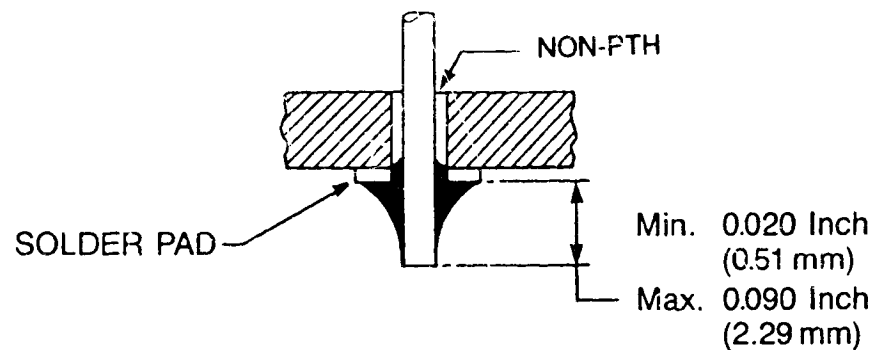


Figure 5-16. Lead Bend

- c. **Straight-through Lead Terminations.** Part leads terminated straight through the PWB shall extend a minimum of 0.020 inch (0.51 mm) and a maximum of 0.090 inch (2.29 mm) (Figure 5-17). The minimum lead length shall be determined prior to soldering (actual measurement is not required except for referee purposes). Straight-through leads may be bent up to 30 degrees from a vertical plane to retain parts during the soldering operation (Figure 5-18). Nonbendable leads shall not be bent.

A



B

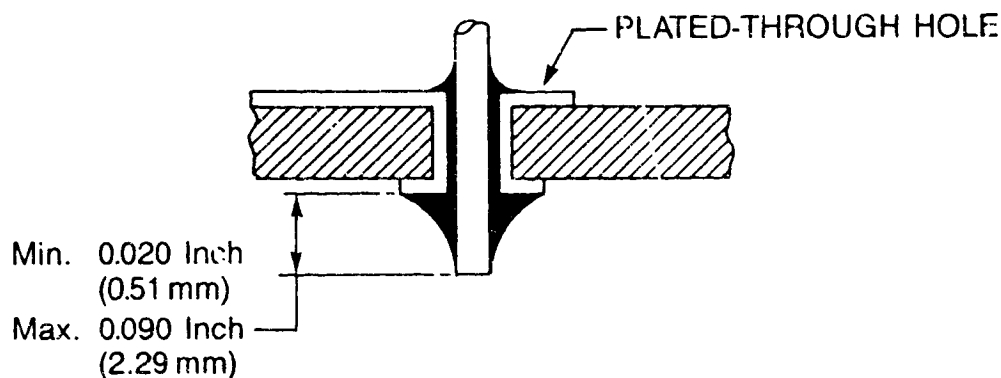
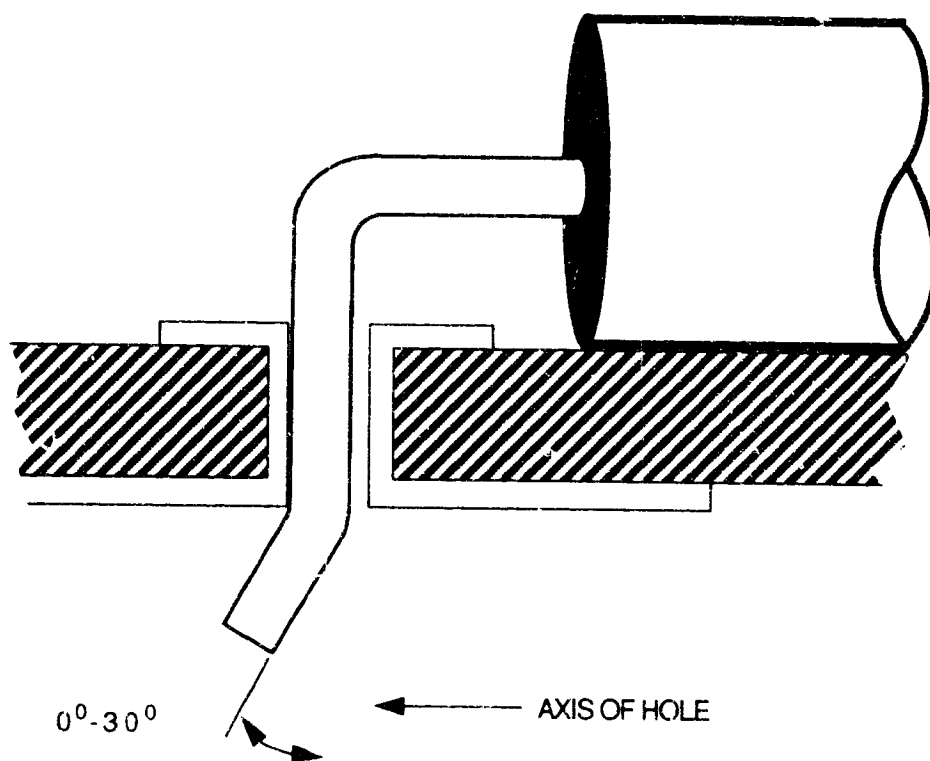


Figure 5-17. Straight-Through Termination



B

Figure 5-18. Straight-through Lead Retention

CHAPTER 6: ATTACHMENT OF CONDUCTORS TO TERMINALS

3A600 General

Parts and conductors shall be attached to terminals as illustrated herein. For terminals not described or illustrated, similar procedures and inspection requirements for attachment of parts and conductors shall be documented by the supplier and submitted for approval in accordance with paragraph 3A102-4.

1. **Minimum Insulation Clearance.** The insulation shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation.
2. **Maximum Insulation Clearance.** The insulation clearance shall be less than two wire diameters, including insulation, but in no case shall permit shorting between adjacent conductors. Insulation clearance shall be referenced from the first point of contact of the conductor to the terminal.
3. **Multiple Parallel Entry.** For multiple parallel entry of conductors to a terminal, insulation clearances need not be equal.
4. **Variations.** When characteristic impedance or other circuit parameters are affected, such as in high-voltage circuits or coaxial line terminations, the insulation clearance requirements may be modified. All variations shall be documented and shall have written approval from the procuring NASA Installation prior to use.
5. **Breakouts from Wire Bundles.** For multiple conductors routed from a common wire bundle to equally spaced soldered terminals, the length of the conductor ends, including bend allowance, shall be uniform to prevent stress concentration on any one conductor.
6. **Mechanical Support.** Wire bundles shall be supported so that the solder connections are not subjected to mechanical loads. The methods, means, and location of this support shall be specified in the design engineering documentation.
7. **Stress Relief.** Conductors shall be provided with sufficient slack to preclude tension on the solder termination or conductor.

8. **Wrap Orientation.** Conductors may be wrapped clockwise or counterclockwise on the terminal and shall continue the curvature of the dress. The conductor shall not interfere with the wrapping of other conductors on the terminal. The curvature of the dress shall not exceed 20° from a perpendicular line from the last point of contact between the conductor and terminal (Figure 6-1).

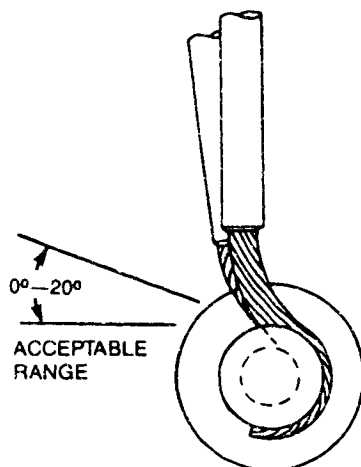


Figure 6-1. Wrap Orientation

9. **Terminal Fill.** Conductors and part leads shall be in full contact with the terminal. They shall not be wrapped onto each other or extend beyond the top of the terminal.
10. **Part Leads.** Part leads shall not be used as terminals unless the part is designed for the lead to function as a terminal.
11. **Mounting of Parts to Terminals.** The mounting of parts shall comply with the requirements of paragraph 3A502 and this chapter.
12. **Terminals.** Hot dipped, tin-lead coated or hot reflowed, electrodeposited tin-lead solder terminals shall be used. Terminals with uneven or excessive coatings on their mounting surfaces shall not be used as they may loosen in subsequent soldering operations. Terminals shall be of proper size to accommodate the conductors. Terminals and conductors shall not be modified except for high voltage applications.

13. **High-Voltage Lead Wrap.** High-voltage lead wraps shall be defined in the engineering documentation.

3A601 TURRET AND STRAIGHT PIN TERMINALS

1. **Side Route.** The side route shall be connected as follows:
 - a. Conductor sizes larger than AWG 26 shall be wrapped more than $1/2$ (180°) to a maximum of $3/4$ turn (270°) around the post (see Figure 6-2A).
 - b. Conductor sizes AWG 26 and smaller shall be wrapped more than $1/2$ turn (180°) but less than one full turn (360°) around the post (see Figure 6-2B).
 - c. For turret terminals, all conductors shall be confined to the guide slots (see Figure 6-3A).
 - d. Conductors shall be maintained in contact with the post for the full curvature of the wrap and the conductor ends shall not extend beyond the base of the terminal.
 - e. More than one conductor may be installed in a single slot of sufficient width, provided each conductor is wrapped on the terminal post and not on another conductor.

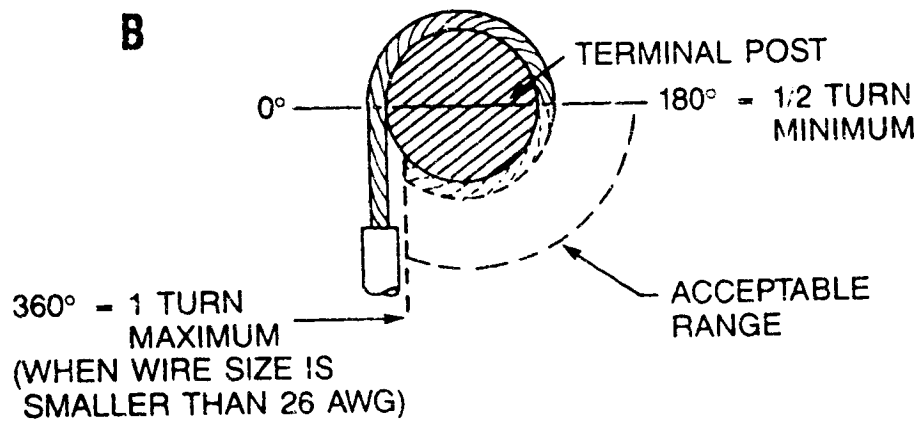
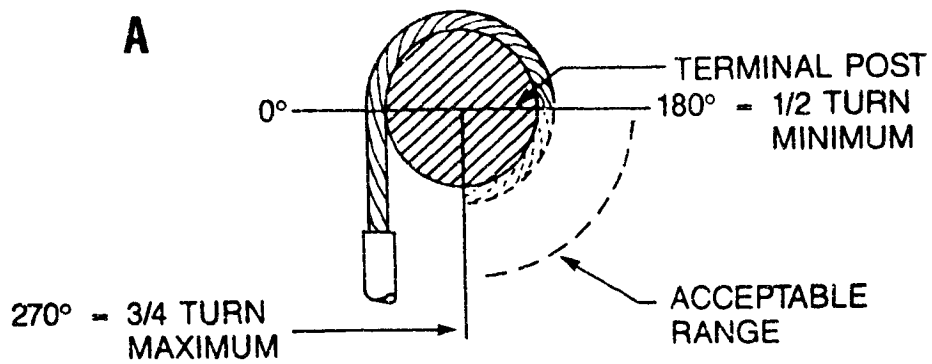


Figure 6-2. Conductor Wrap

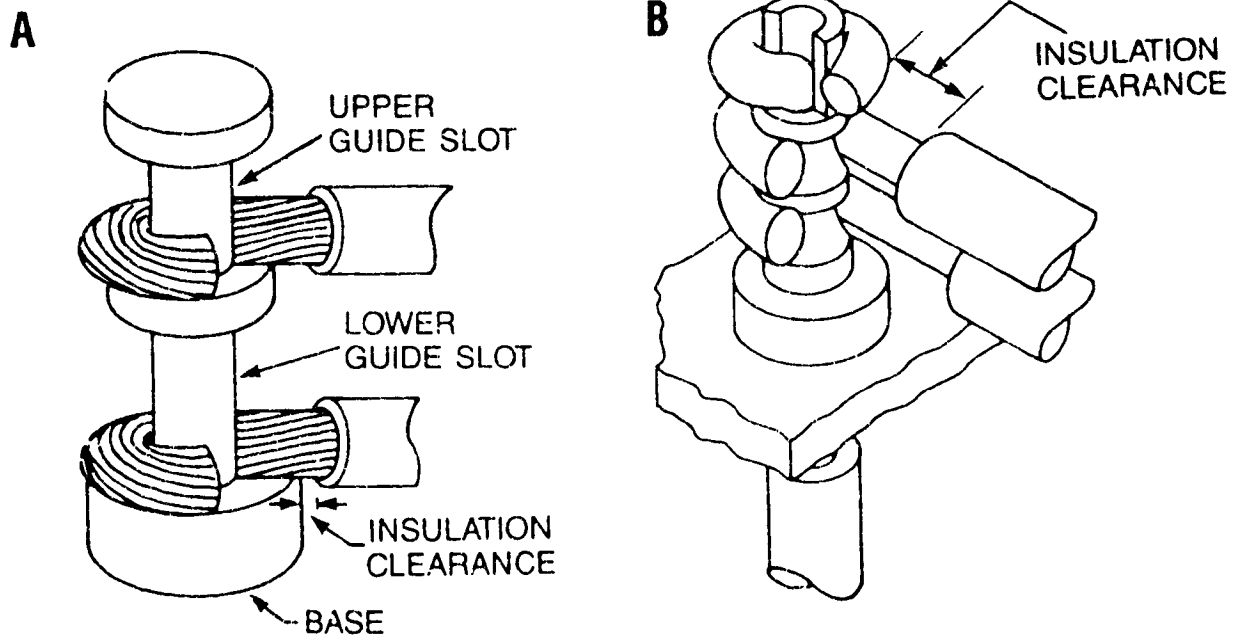


Figure 6-3. Turret Terminal

2. **Bottom Route.** The conductor shall enter the terminal from the bottom, be brought through the side slot at the top, and wrapped as required for side route (Figure 6-3B).
3. **Continuous Run Wrapping.** If three or more terminals in a row are to be connected, a solid bus wire jumper may be continued from terminal to terminal as shown in Figure 6-4. The wrap to the first and last terminal of the series shall conform to paragraph 3A601-1a or paragraph 3A601-1b depending on conductor size.

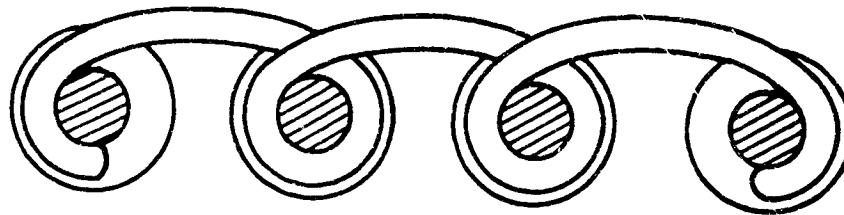


Figure 6-4. Continuous Run Wrapping, turret terminals

3A602 BIFURCATED TERMINALS

1. **Bottom Route.** Bottom route shall be connected as shown in Figure 6-5. Conductors shall not extend beyond the diameter of the base except as shown in Figure 6-5C, which is acceptable only when physical clearance is adequate for the intended environment or electrical characteristics. When more than one conductor is to be attached, it shall be inserted at the same time but shall be wrapped separately around alternate posts.

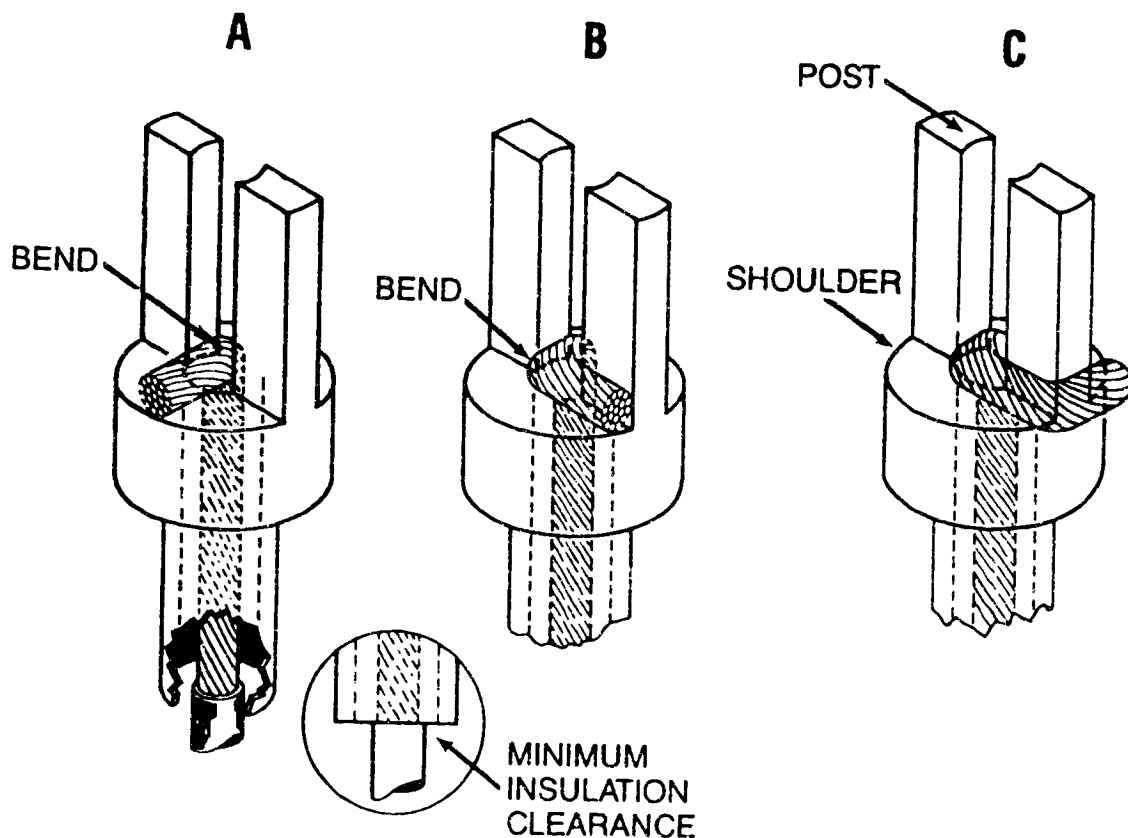


Figure 6-5. Bottom Route Connections to Bifurcated Terminals

2. **Side Route.** Side route shall be connected as follows (Figure 6-6):
 - a. The conductor shall enter the mounting slot perpendicular to the posts.
 - b. A conductor may lay straight through a terminal slot provided the conductor surface remains in contact with the terminal surface (Figure 6-6A). Where conductors are wrapped on a terminal post, they shall wrap a minimum of 90° and a maximum of 180° (1/4 to 1/2 turn), refer to Figure 6-7.
 - c. More than one conductor may be installed on a single post provided each conductor is wrapped on the terminal post and not on another conductor.

- d. When more than one conductor is connected to a terminal, the direction of bend of each additional conductor shall alternate (Figures 6-6B and D).
 - e. Conductors shall not extend beyond the diameter of the base except as shown in Figure 6-6C, which is acceptable only where physical clearance will not adversely affect environmental and electrical characteristics.
3. **Side and Bottom Route.** The bottom route shall be installed first as shown in Figure 6-5, then the side route as shown in Figure 6-6.

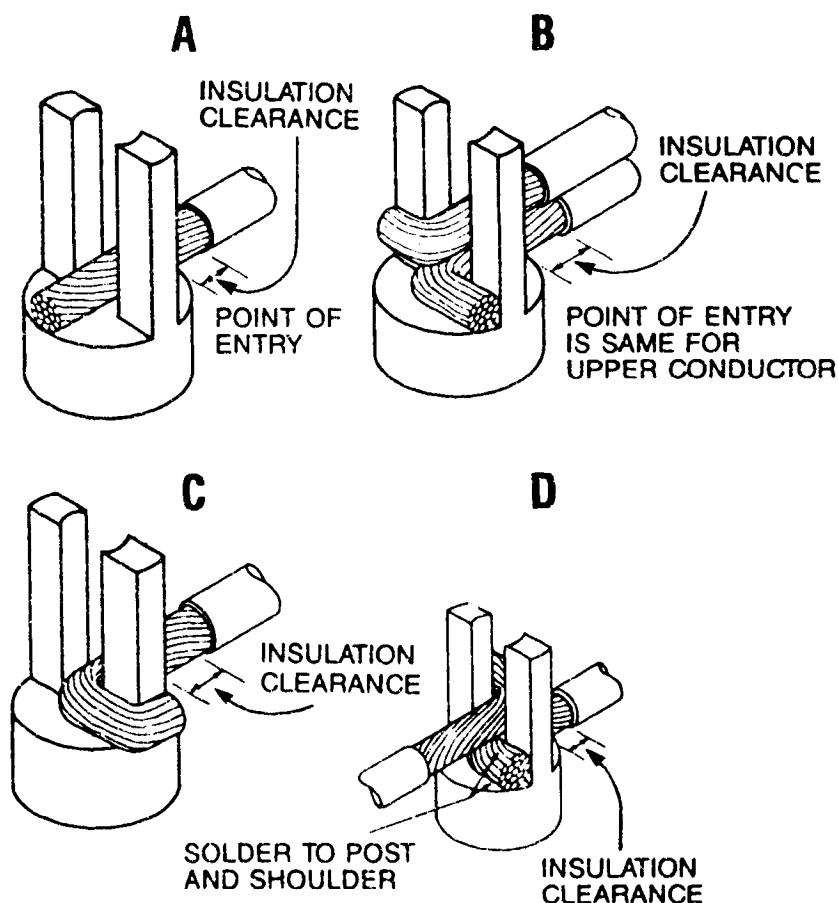


Figure 6-6. Side Route Connections to Bifurcated Terminals

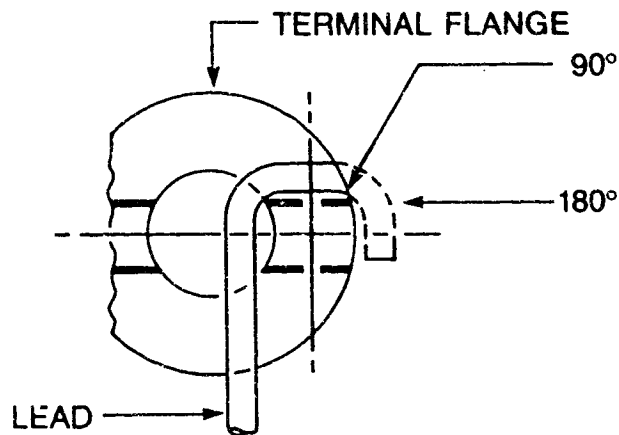


Figure 6-7. Lead Wrap

4. **Continuous Run Connections.** When a series of terminals are to be connected to each other, such interconnections shall be made with a solid wire in accordance with Figures 6-8 or 6-9. The wire shall be attached to the first and last terminal in accordance with paragraph 3A602-2.

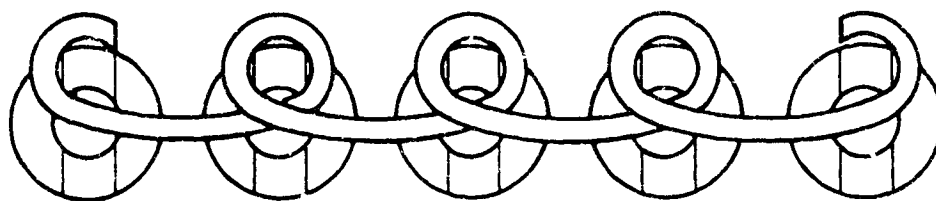


Figure 6-8. Continuous Run Wrapping, Bifurcated Terminals

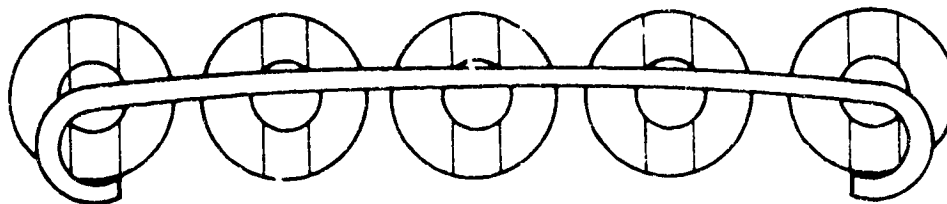


Figure 6-9. Continuous Run Wrapping, Bifurcated Terminals
Alternate Procedure

3A603 HOOK TERMINALS

Connections to hook terminals shall be as shown in Figure 6-10. The bend to attach conductors to hook terminals shall be a minimum of $1/2$ turn (180°) to a maximum of $3/4$ turn (270°). Protrusion of the conductor ends shall be controlled to avoid damage to the insulation sleeving. Conductors shall be wrapped directly to the terminal and not on other conductors. When more than one conductor is connected to the terminal, the direction of the bend of each additional conductor shall alternate (Figure 6-10).

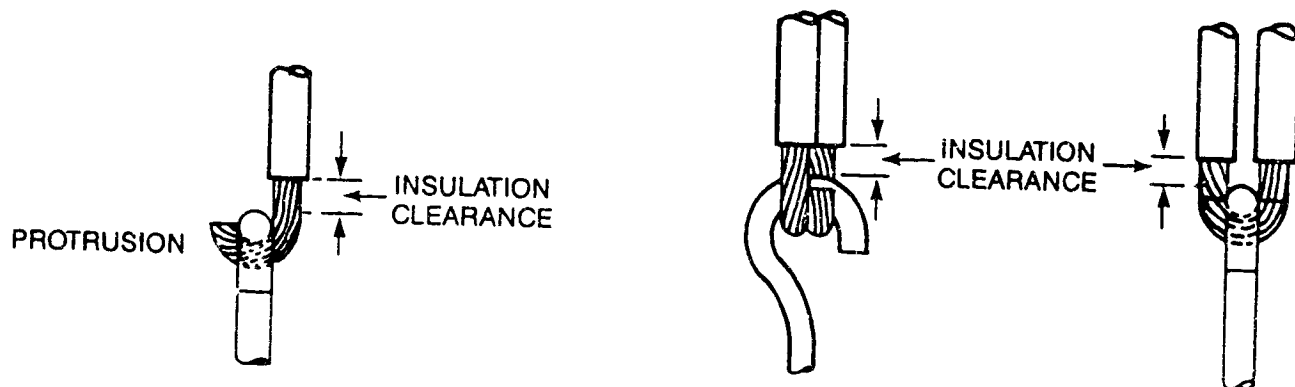


Figure 6-10. Connections to Hook Terminals

3A604 PIERCED TERMINALS

Connections to pierced terminals shall be as shown in Figure 6-11. The bend to attach conductors to pierced terminals shall be a minimum of $1/4$ turn (90°) to a maximum of $1/2$ turn (180°). Protrusion of conductor ends shall be controlled to avoid damage to insulation sleeving.

3A605 SOLDER CUPS (CONNECTOR TYPE)

Conductors shall enter the solder cup as shown in Figure 6-12. Conductors shall be bottomed in the cup and shall be in contact with the inner wall of the cup. The maximum number of conductors shall be limited to those which can be in contact with the full height of the inner wall of the cup.

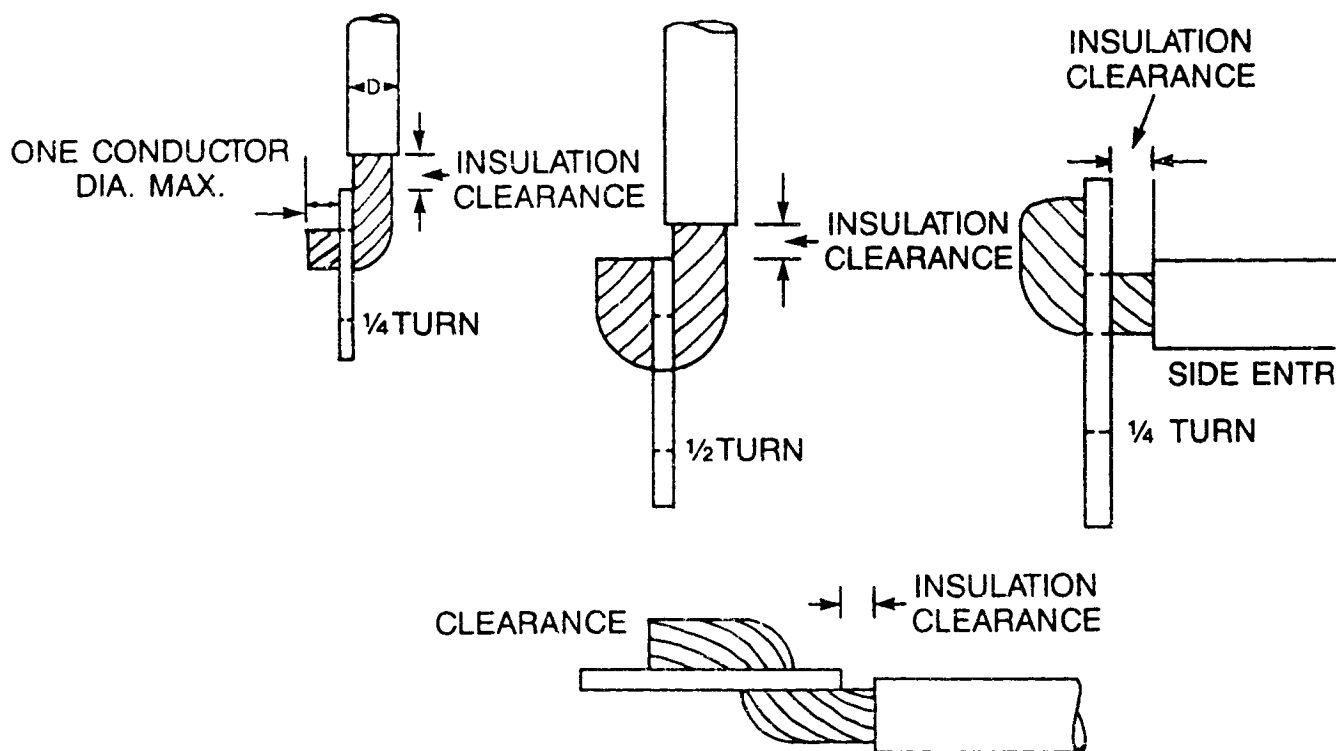


Figure 6-11. Connections to Pierced Terminals

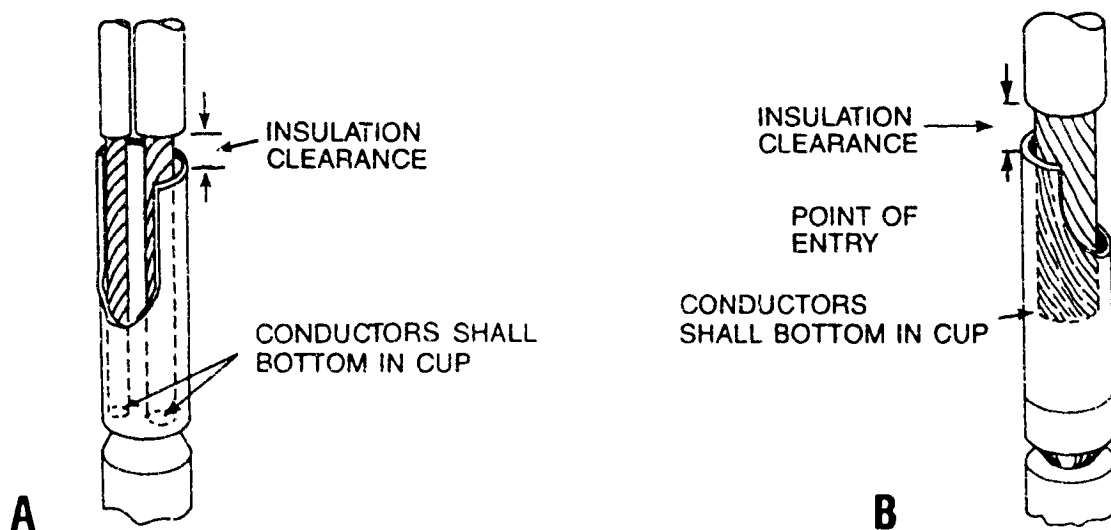


Figure 6-12. Connections to Solder Cups (Connector type)

3A606 SOLDER CUPS (SWAGED TYPE)

Connection shall be as shown in Figure 6-13. Conductors entering from the top shall be in contact with the inner wall of the cup and shall bottom in the cup or on the bottom conductor.

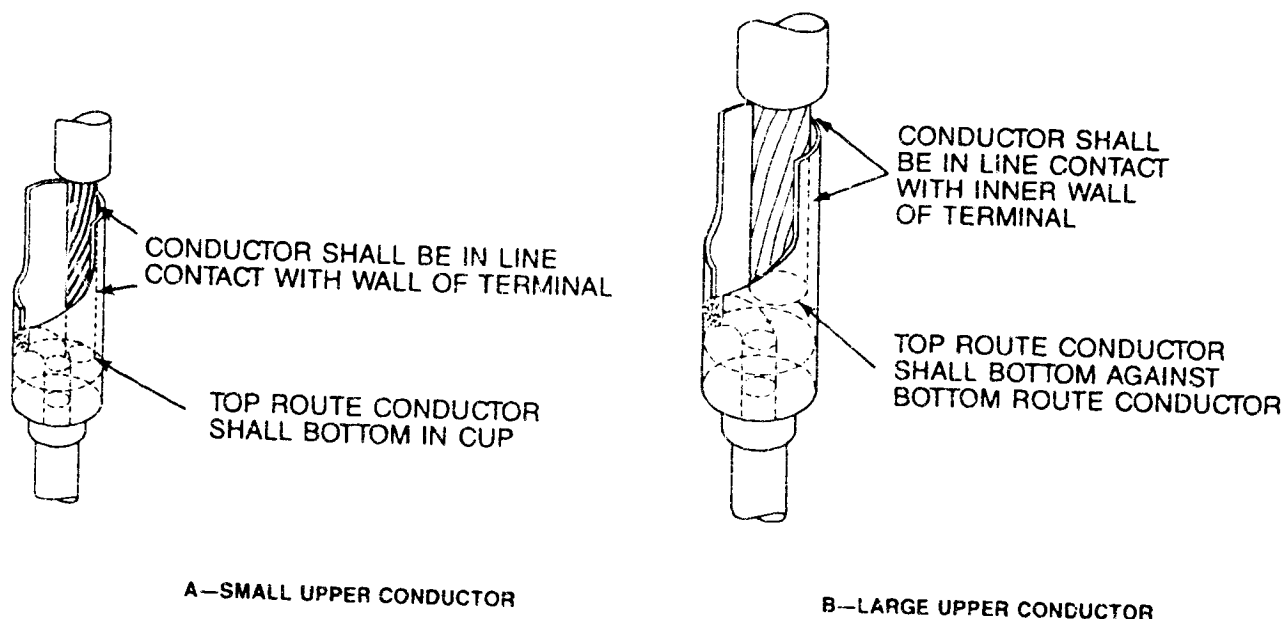


Figure 6-13. Connections to Swaged Type Solder Cups

3A607 INSULATION SLEEVING APPLICATION

All joints required to be covered by insulation sleeving shall be inspected prior to and after sleeving. Heat shrinkable insulation sleeving shall be used for electrical insulation as appropriate. For example, elements (such as hook terminals, solder cups, and bus wires), that are not protected by insulating grommets, potting, or conformal coating, shall be protected with insulating sleeving. Where a part covered by insulating sleeving requires mechanical support, measures shall be taken to ensure that the part is not free to move within the sleeving. Material selection shall be specified in the engineering documentation. **Sleeving shall not be pierced, split, charred, or otherwise damaged.**

CAUTION

EXTREME CARE SHALL BE TAKEN TO PREVENT DAMAGE TO THE ASSEMBLY DUE TO EXCESSIVE HEAT WHILE SHRINKING THE SLEEVING.

CHAPTER 7: SOLDERING TO TERMINALS

3A700 GENERAL

1. **Securing Conductors.** There shall be no motion between conductors and the terminal during soldering or while the solder is solidifying.
2. **Thermal Shunts.** Thermal shunts shall be used where heat during the soldering operations may degrade conductors, insulation, parts, or previously soldered connections.
3. **Inspection.** The criteria for inspection can be found in Chapter 10.
4. **Cooling.** Pressurized air shall not be used to cool solder joints. Connections shall only be cooled at room temperature.

3A701 SOLDER APPLICATION

1. **Solder Coverage.** The molten solder shall flow around the conductor and over the termination area. Solder quantity and filleting shall be as shown in Appendix B except for high voltage connections.
2. **Terminals.** A fillet of solder shall be formed between the terminal and each side of the conductor except for cup terminals.
 - a. **Cup Terminals**
 - (1) The solder shall form a fillet between the conductor and the cup entry slot. The fillet shall follow the contour of the cup opening within the limits illustrated in Appendix B, Typical Acceptable Solder Connections.
 - (2) Solder along the outside surface of the solder cup is permissible to the extent that it approximates tinning and does not interfere with the assembly or function of the connector.
3. **Wicking.** Flow (wicking) of solder along the conductor is permitted. Solder shall not make the presence of the individual wire strands indistinguishable.

4. **High Temperature Soldering.** During soldering operations where terminals are subsequently reheated, the use of high temperature solder is permitted. The solder used shall conform to the requirements specified in paragraph 3A310-2.

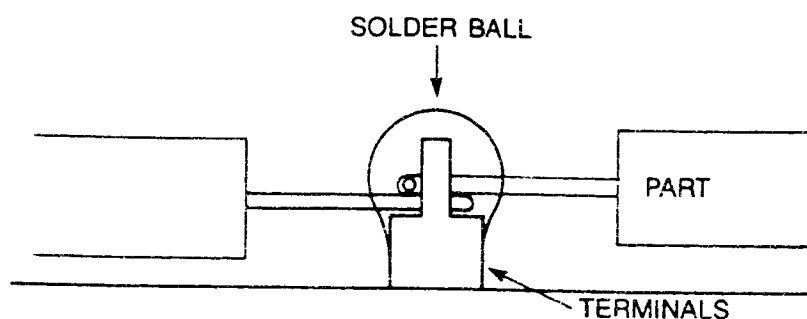
3A702 HIGH VOLTAGE TERMINATIONS

1. Where soldering of high voltage terminations is required, all elements of the terminations shall be covered by a smooth fillet, free of discontinuity or severe change in contour. There shall not be any projections from part leads or solder spikes.
2. Prior to soldering, all areas that will be joined together by solder shall be pretinned. Parts and termination surfaces shall be examined for solderability after the tinning operation to assure that wetting will not be hindered.
3. All solder terminations shall be soldered as specified in paragraph 3A701. On completion, the solder terminations shall be inspected for workmanship. After inspection is complete, and the terminations are acceptable, the terminations shall be solder balled (see Figure 7-1).

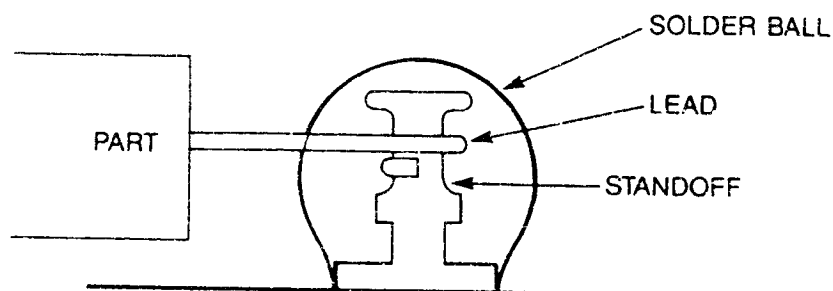
3A703 SOLDER CLEANING

1. **Interim Cleaning.** Residues shall be removed during interim cleaning within $\frac{1}{2}$ hour after soldering by applying an approved noncorrosive solvent as specified in paragraph 3A312. Solvents shall be applied in a manner that will minimize entry of the solvent under conductor insulation and prevent its entry into the interior of parts.
2. **Final Cleaning.** Mechanical means such as agitation or brushing may be used in conjunction with the solvents. The cleaning solvents and methods used shall have no deleterious affect on the parts, connections, and materials being cleaned. Ultrasonic cleaning shall not be used for cleaning assemblies that contain electronic parts. After cleaning, there shall be no visible evidence of flux residue or other contamination when examined. PWA cleanliness shall be verified in accordance with Chapter 11.

3. **Cleaning of Conformal Coated Assemblies.**
Conformal coated assemblies that require rework shall not be submerged in cleaning solvents. Cleaning shall be limited to the area of rework.



ACCEPTABLE PART INTERCONNECTION



ACCEPTABLE STANDOFF CONNECTION

Figure 7-1. Solder-Ball Termination

CHAPTER 8: HAND SOLDERING OF PRINTED WIRING ASSEMBLIES

3A800 GENERAL

1. **Securing Conductors.** There shall be no relative motion between conductors, terminals, and PWB termination areas during solder application and solidification. Conductors shall not be temporarily constrained against spring-back force during solder solidification which may produce residual stress in the joint.
2. **Thermal Shunts.** Thermal shunts shall be used where heat during the soldering operations may degrade conductors, insulation, parts, or previously soldered connections.
3. **Inspection.** The criteria for inspection can be found in Chapter 10.
4. **Dip Soldering.** Dip soldering of PWA's is not permitted.
5. **Pattern Repair.** Repair of damaged or broken conductor patterns on PWB's is not permitted.
6. **Solder Rework.** Rework of soldered PWA's shall be performed in accordance with the soldering requirements of this publication.
7. **Cooling.** Pressurized air shall not be used to cool solder joints. The connection shall be cooled at room temperature only.
8. **High-Voltage Connections.** High-voltage connections where corona suppression is necessary shall be as defined in engineering documentation. Where soldering of high voltage connections is required, all elements of the connection shall be covered by a smooth fillet and free of discontinuity or severe change in contour.

3A801 SOLDER APPLICATION

1. **Solder Coverage.** The molten solder shall flow around the conductor and over the termination areas. Solder quantity and filleting shall be as shown in Appendix B.
2. **Nonplated Through Hole Soldering.** Solder fillets shall be complete and as shown in Appendix B.

3. Plated Through Hole Soldering

- a. In soldering a conductor into a PTH, heat may be applied to either or both sides of the PTH, but solder shall only be applied to one side (all board types).
- b. On the solder application side of the PTH, the quantity of solder shall meet all the requirements established by this document.
- c. For the connection on the PTH side opposite from the solder application, the solder quantity shall as a minimum exhibit flow-through and bonding of the lead or conductor to the solder pad; but not necessarily wetting out to or around the entire periphery of the solder pad. A slight recessing or shrinkback of the solder into the PTH below the solder pad shall be acceptable providing the solder has obviously wetted the lead and solder pad and the shrinkback is slight enough that it can not be construed to be a solder void or blow hole.

CAUTION

WHEN SOLDERING PTH'S THAT HAVE LARGE GROUND PLANE ATTACHMENTS AND/OR LARGE TRACES TERMINATING AT THE PTH, SPECIAL SOLDER PROCEDURES MAY BE REQUIRED.

4. Interfacial Connections

- a. **Double-Sided PWB's.** PTH's on double-sided PWB's requires the use of filler wire for support. Solder filled PTH's are not acceptable on double sided PWB's.
- b. **Multilayer PWB's.** Multilayer PWB PTH's, used as vias do not require the use of filler wire nor shall they be solder filled. However, no dedicated effort shall be expended to remove solder in unused holes.

CAUTION

WHEN SOLDERING TO PTH'S ON MULTILAYER PWB'S CARE SHOULD BE EXERCISED TO PREVENT HEAT DAMAGE TO THE PTH AND THE JUNCTION OF INTERNAL TRACES CONNECTED TO THE PTH.

5. Lap Terminations

- a. A heel fillet is mandatory for all single surface lapped solder joints. The heel fillet shall be continuous between the heel of the lead and the termination pad. The heel fillet shall extend beyond the lower bend radius but shall not extend into the upper bend radius (see Figure 8-1).
- b. Round lead lap terminations require a complete solder fillet around all sides of the lead (see Figure 8-2).
- c. On ribbon lead lap terminations where one side of a lead is flush with the edge of the termination pad, a fillet of solder shall be present along at least two of the other three sides of the lead.

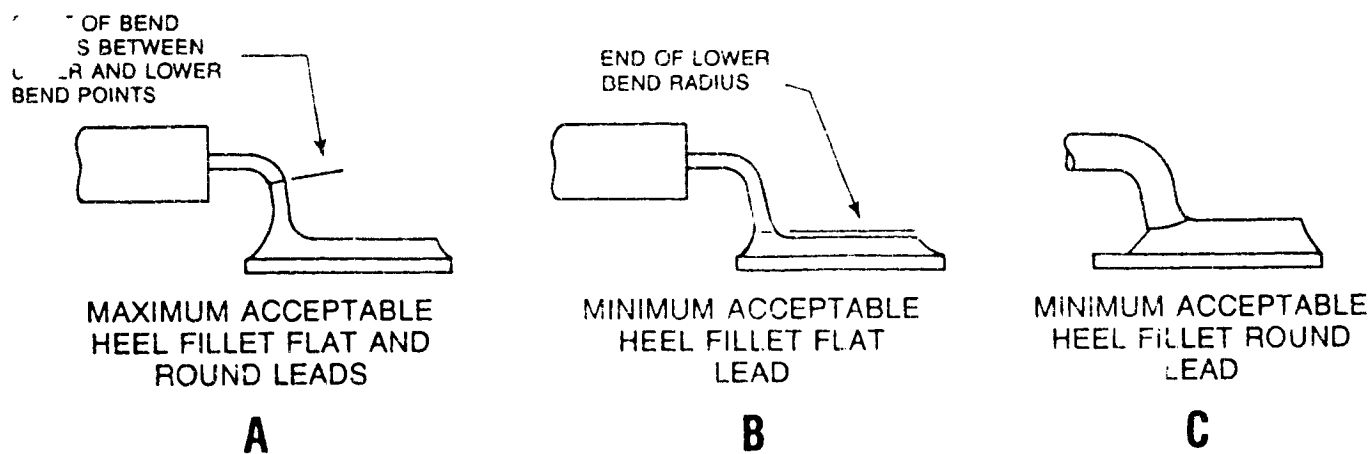


Figure 8-1. Heel Fillet

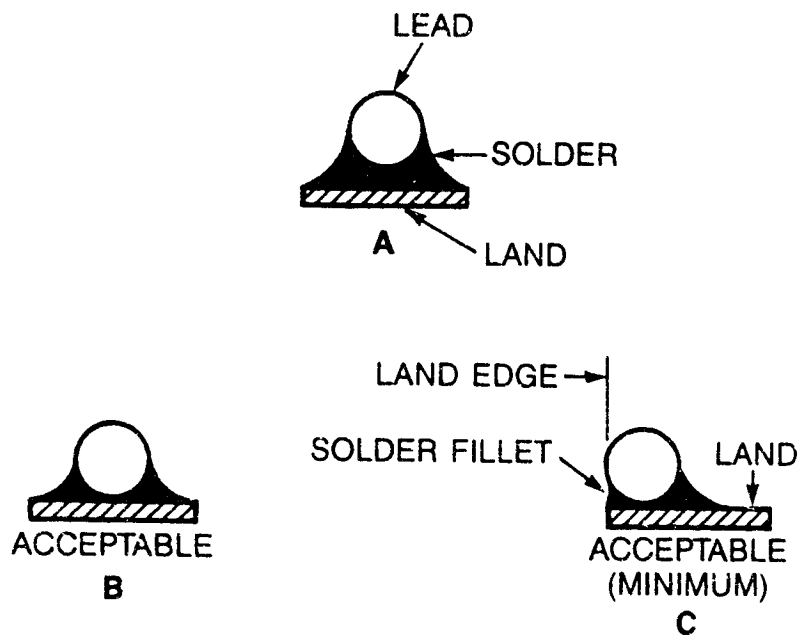


Figure 8-2. Round Lead Termination

3A802 SOLDER CLEANING

Cleaning solder connections during and after soldering shall be performed in accordance with paragraph 3A703 and verified in accordance with Chapter 11.

CHAPTER 9: AUTOMATIC WAVE SOLDERING

3A900 GENERAL

This chapter contains requirements peculiar to automatic wave soldering.

1. The supplier's process documentation for automatic wave soldering operations shall define:
 - a. Preheat temperature.
 - b. Temperature of the solder.
 - c. Conveyor speed and angle.
 - d. Height of the solder wave.
 - e. Flux density.
 - f. Flux height.
 - g. Depth of PWA in wave.
 - h. Control of the dross inhibitors.
 - i. Allowable contaminants when the solder bath is analyzed.
 - j. Frequency of maintenance and of analysis and other factors affecting the quality of the connections in the end product.

Maintenance and calibration data shall be available for inspection.

2. **Solder.** The solder used shall be tin-lead conforming to composition SN60 or SN63, type S of QQ-S-571.
3. **Flux.** Liquid flux solutions shall be specified as to composition and concentration. Concentration shall be controlled within specified limits by periodic measurement (e.g., specific gravity determination) and adjustment on a predetermined schedule.
 - a. **Rosin Base Flux.** The soldering flux shall be noncorrosive and nonconductive and shall meet the requirements as specified in paragraph 3A311. A compatible thinner solution may be added to liquid rosin flux.

- b. **Water Soluble Flux.** This flux shall be an organic composition (acid, halogen amine, or amide) and moderately active. It shall have been demonstrated to be noncorrosive when used in the wave soldering application and be readily removed by water. Prior approval by the procuring NASA Installation must be obtained for the use of this flux.
- 4. **Solvents.** Water with a wetting agent additive or other solvents as specified in paragraph 3A312 shall be used as appropriate for cleaning PWA's. However, the use of wetting agents should be followed by a thorough deionized water rinse and drying. PWA's must then be kept dry until conformally coated.
- 5. **Oil.** When oil is used to reduce surface tension and oxidation of the liquid solder, it shall be selected by using the following criteria:
 - a. Thermal stability or low evaporation loss.
 - b. Length of "use life" before a change is necessary.
 - c. Weight loss.
 - d. Boiling point.
 - e. Wetting ability.
 - f. Ease of removal from PWA after soldering operation.

3A901 PREPARATION AND ASSEMBLY

- 1. Only PWB's with tin-lead (solder) coated or reflowed electroplated tin-lead coated conductor patterns shall be wave soldered.
- 2. Parts shall be mounted as specified in Chapter 5 of this document. The mounting shall prevent relative motion between the part and PWB during solder solidification. If temporary clamping is used, it shall not result in residual solder joint stresses from lead springback forces.
- 3. The assembled PWB's shall be cleaned and demoisturized prior to wave soldering. The bakeout time and temperature shall be established and defined in the supplier's process

documentation. Demohisturizing shall be performed within 8 hours of wave soldering. Bakeout time and temperature, and the time in and time out of the oven or chamber shall be recorded. The assembled PWB's may be stored for longer periods of time in a controlled moisture free atmosphere.

4. Metal surfaces, not to be soldered, shall be masked or coated with a solder resist prior to loading.

3A902 PROCESS PARAMETERS

Wave solder parameters, as defined in paragraph 3A900-1, shall be determined prior to wave soldering of production assemblies. A sample representing the production PWA shall be used to develop the parameters.

3A903 WAVE SOLDERING

1. The preheat temperature shall be controlled to a selected PWB temperature between 170°F (76.7°C) and 225°F (107.2°C). The heater temperature shall be maintained within 5°F (2°C).
2. The conveyor speed shall be controlled to a preselected rate, and shall not vary more than 1 inch (25.4 mm) per minute.
3. Solder temperature shall be controlled so that the solder in the wave making contact with the PWA is 480°F (248.9°C) to 525°F (273.9°C).
4. The height of the solder wave shall be controlled to a constant preselected height.
5. The solder bath shall be analyzed on an established schedule, based on usage, to assure it meets the requirements of Table 4-1, and that the total of gold plus copper does not exceed 0.3 percent. Anytime the solder produces a dull, frosty, or granular appearance on the work, the bath shall be removed from use.
6. The oil shall be analyzed or replaced on an established schedule based on usage and degradation.
7. A wave soldering log shall be maintained showing the process parameters as established in paragraph 3A902 for each PWA type, in order to repeat previously successful runs. The log shall also be

prescribed in subparagraphs 5 and 6 of this paragraph.

3A904 CLEANING

1. After soldering, the flux, dross inhibitor, temporary solder resist, and oil shall be promptly removed in a manner that does not damage the hardware or degrade the part marking legibility. This shall be accomplished by use of an appropriate solvent meeting the requirements of paragraph 3A312, followed by rinsing with clean solvent to ensure complete removal of the residues.
2. Where water soluble fluxes are used, there shall be no more than a 30-minute delay between the cooling of the PWA to the temperature of the cleaning solvent and the actual cleaning. In addition, no more than 30 minutes delay is allowed between cleaning and the final rinsing with deionized water in a controlled rinse bath.
3. The final rinse bath shall be monitored by resistivity measurements made at established intervals to pre-established resistivity limits. Intervals shall be based on the number and size of PWA's cleaned, as well as time required to produce the lot. Refer to Chapter 11 for cleanliness requirements.

3A905 INSPECTION

Inspection criteria listed in Chapter 10 are applicable to wave soldered assemblies. Warp or twist of the PWA shall not exceed the limits specified by the engineering documentation.

CHAPTER 10: QUALITY ASSURANCE PROVISIONS

3A1000 GENERAL

1. **Workmanship.** Workmanship shall be of a level of quality adequate to assure that the processed products meet the performance requirements of the engineering documentation and criteria delineated herein.
2. **Inspection.** Inspection for acceptability shall be performed on all solder connections, parts mounting, conductor routing, part condition, and PWB features to the requirements specified in this document. Parts and conductors shall not be physically disturbed to aid inspection. The visual workmanship standard for typical solder connections is shown in Appendix B.
3. **Method of Inspection.** Visual inspection of all soldered connections shall be performed. Where visual inspection is not possible, other non-destructive means (e.g., laminography, microfocus X-ray, fiberscope optics) shall be used.
4. **Quality Assurance.** The following functions shall be performed:
 - a. Verify that all tests, inspections, and measurements specified by this document have been performed.
 - b. Verify that all personnel who assemble or inspect hardware in accordance with this document have been trained and certified as specified in Chapter 2.
 - c. In-process surveillance of all assembly operations to verify that all processes and procedures implementing the requirements of this document are current, approved, adequate, and being accurately utilized.
 - d. Verify that no damage exists on parts and PWB's prior to their being assembled and soldered. In addition, parts and PWB's shall be inspected to verify that solderability has been maintained.
 - e. Verify that the facility cleanliness, environmental conditions, and lighting requirements of Chapter 3 are being met.

3A1001 MAGNIFICATION AIDS

Inspection optics shall conform to the requirements of paragraph 3A307. Visual inspection shall be aided by magnification between 4X and 10X. Additional magnification shall be used as necessary to resolve suspected anomalies or defects.

3A1002 DOCUMENTATION VERIFICATION

Quality Assurance personnel shall verify that all required documentation is current and approved. The documentation shall include:

1. Records

- a. Results of the visual examination as per paragraph 3A201-1.
- b. Evidence of operator and inspector certification as per paragraph 3A204.
- c. Environmental monitoring as per paragraph 3A301-1.
- d. Production and inspection tool calibration as per paragraph 3A303-2d.
- e. Solder pot and bath analyses as per paragraphs 3A401-5c and 3A903-5.
- f. Wave soldering log as per paragraph 3A903-7.
- g. Lead tinning deviation inspection results as per paragraph 3A401-5a.
- h. Demoisurizing as per paragraphs 3A402-3 and 3A901-3.
- i. Cleanliness level results as per paragraph 3A904.

2. Procedures

- a. Soldering program as per paragraphs 3A103-1 and 3A200.
- b. Training and certification program as per paragraph 3A203-2b.
- c. Tooling and equipment operating procedures as per paragraph 3A303-1e.

- d. Calibration system as per paragraph 3A303-2.
- e. Use of supplemental heat sources as per paragraph 3A304-6.
- f. In-process storage and handling procedures as per paragraph 3A308-1.
- g. ESD control program as per paragraph 3A308-3.
- h. Flux usage as per paragraph 3A311-1.
- i. Wave soldering procedure as per paragraph 3A900-1.
- j. Cleaning procedures as per paragraph 3A1100.

3A1003 DOCUMENTATION AUTHORIZATION

Quality assurance shall verify that the following documentation has been approved by the procuring NASA Installation prior to implementation:

- 1. Special engineering requirements as per paragraph 3A100-3.
- 2. Special soldering processes, materials, or connections as per paragraph 3A102-4.
- 3. Deviations and waivers as per paragraph 3A105.
- 4. Repair as per paragraph 3A106-2.
- 5. Process documentation for special tools as per paragraph 3A303-3.
- 6. Chemical stripping methods as per paragraph 3A305-2c.
- 7. Special solders, fluxes, and solvents as per paragraphs 3A310, 3A311, and 3A312.
- 8. Water based saponifier and detergent as per paragraph 3A312-6.
- 9. Special tinning processes as per paragraph 3A401-5b.
- 10. Nondestructive inspection method as per paragraphs 3A503-1 and 3A1000-3.

11. Attachment of conductors to terminals not in accordance with paragraph 3A600.
12. Water soluble flux used in wave soldering as per paragraph 3A900-3b.
13. Special cleanliness test methods as per paragraph 3A1101-3.

3A1004 VERIFICATION OF TOOLS, EQUIPMENT, AND MATERIALS

1. **Tools and Equipment.** Tools and equipment shall be verified for conformance to the applicable requirements as found in paragraph 3A303.
2. **Material.** All materials shall conform to the requirements of paragraphs 3A310 through 3A312. Material controls shall be implemented to ensure that only conforming materials are used. Materials not conforming or not required for the operations involved shall be removed from the work area or tagged nonusable.
 - a. **Solderability.** Solderability of materials shall be verified for compliance with the requirements of paragraph 3A309.

3A1005 INSPECTION CRITERIA

1. **Acceptance Criteria.** Acceptance criteria are described in Chapters 1 through 9 and the following:
 - a. The appearance of the solder joint surface shall be smooth, nonporous, undisturbed and shall have a finish that may vary from satin to bright depending on the type of solder used.
 - b. Solder shall wet all elements of the connection, except as noted in paragraph 3A1005-1f(2). The solder shall fillet between connection elements over the complete periphery of the connection as illustrated in Appendix B.
 - c. A heel fillet is mandatory for all single surface (not through PWB) lapped solder joints.

- d. The lead contour shall be visible (except high-voltage connections; see paragraph 3A702-3).
 - e. Complete wetting (except for PTH's).
 - f. PTH soldering
 - (1) On the solder application side, the quantity of solder shall meet all requirements established by this document.
 - (2) On the side opposite from the solder application, the solder quantity shall, as a minimum, exhibit flow through and bonding of the lead or conductor to the solder pad. A slight recessing or shrinkback of the solder into the PTH below the solder pad is acceptable, providing the solder has obviously wetted the lead and onto the solder pad and the shrinkback is slight enough that it can not be construed to be a solder void or blowhole. Also, slight dewetting of the solder around the periphery of the pad on the part side of the PWB is not cause of rejection.
 - g. The presence of wire bundle supports as identified in the engineering documentation.
 - h. The presence of stress relief in leads or conductors to provide freedom of motion between points of constraint.
 - i. Support of parts as identified in the engineering documentation.
 - j. Part marking visible as identified in paragraph 3A500-3.
 - k. Exposed ends of leads on straight through terminations after soldering shall not be cause for rejection if the PWA is to be conformally coated.
 - l. Absence of the defects as enumerated in paragraph 3A1005-2.
2. **Rejection Criteria.** The following are some characteristics of unsatisfactory conditions, any of which are cause for rejection:

a. Conductors and Parts

- (1) Nicks, cuts, and crushing or charring of insulation (slight discoloration from thermal stripping is acceptable).
- (2) Improper insulation clearance.
- (3) Improper tinning of part leads or conductors.
- (4) Separation of wire strands (birdcaging).
- (5) Part improperly supported or positioned (polarity, centering, planarity).
- (6) Improper vertical mount of component clearance.
- (7) Part damaged.
- (8) Cut, nicked, stretched, or scraped leads or wires exposing base metal (except smooth impression marks resulting from bending tool holding forces).
- (9) Flux residue or other contaminants.
- (10) Improper wrap or stress relief.
- (11) Improper positioning of lead to solder pad for lap terminations.
- (12) Epoxy on unsleeved glass parts.
- (13) Unsupported hookup wires in excess of 1 inch length.
- (14) Swaging not in accordance with paragraph 3A501-1b.
- (15) Improper lead bending and cutting.
- (16) Splices used to repair broken or damaged conductor.
- (17) Breakout of conductors from wire bundles not in accordance with paragraph 3A600-5.
- (18) Part leads used as terminals except when the part lead is designed as a terminal.
- (19) Terminals or wires modified to fit.

- (20) Improper clinch length.
- (21) Improper lead protrusion through PWB.
- (22) Part lead more than 0.010 inch above solder pad on lapped termination.
- (23) A part obscuring the solder termination of another part, unless sequential inspection was performed.
- (24) No filler wire in PTH's or double sided PWB's.

b. Solder connections

- (1) Cold solder connection.
- (2) Overheated solder connection.
- (3) Fractured or disturbed solder connection.
- (4) Poor wetting.
- (5) Blowholes, pinholes, and voids (except pits as defined in Appendix A).
- (6) Excessive solder (e.g., solder in the bend radius of axial leaded parts in PTH's is not cause for rejection, provided the lead is properly formed, the topside bend radius is discernible, and the solder does not extend to within 1 lead diameter of the part body or end seal).
- (7) Insufficient solder.
- (8) Splattering of flux or solder on adjacent areas.
- (9) Rosin solder joint.
- (10) Contamination (e.g., lint, flux, dirt).
- (11) Dewetting.
- (12) Non-wetting.
- (13) Part body (meniscus) in solder joint.

c. Printed wiring board

- (1) Separation of conductor pattern from base laminate.
- (2) Burns on base laminate.
- (3) Discoloration that bridges uncommon conductors (e.g., measling, halo effect).
- (4) Solder peaks, icicles, and bridging on conductor patterns.
- (5) Cut, nicked, gouged, or scraped printed wiring conductor that exposes base metal (except for vertical edges).
- (6) Cut, nicked, gouged, or scraped base laminate that exposes glass fibers.
- (7) Delamination of the PWB base laminate.
- (8) Solder mask tackiness, flaking, or separation from the base laminate or conductors.
- (9) Repaired or damaged printed wiring conductor pattern.
- (10) Blisters.

CHAPTER 11: CLEANLINESS REQUIREMENTS

3A1100 GENERAL

All cleaning procedures shall be specified in the supplier's process documentation.

3A1101 CLEANLINESS TESTING

1. Cleanliness testing is used to monitor the effectiveness of post soldering, PWA cleaning processes. All PWA's shall be tested prior to conformal coating.
2. Two basic test methods are recommended.
 - a. Resistivity of solvent extract (paragraph 3A1104).
 - b. Sodium chloride (NaCl) salt equivalent ionic contamination test (paragraph 3A1105).
3. Other test methods must be approved by the procuring NASA Installation before use.

3A1102 TESTING FREQUENCY

1. Testing shall be performed with sufficient frequency to ensure compliance with the requirements of paragraph 3A1103 test limits. At a minimum, this shall consist of once per shift, and immediately prior to changing the cleaning solvent solution.
2. It is recommended that statistical process control methods be used to control continuous solvent cleaning processes. Records of relevant readings shall be maintained for early detection of a trend towards an out of specification condition.
3. In the event that the result of a test is unacceptable, all the PWA's that were cleaned between the previous passed test and this failed test are considered unacceptable.
4. Failed PWA's shall not be recleaned until appropriate corrective actions have been performed on the cleaning system to ensure its correct operation.



3A1103 TEST LIMITS

1. **Resistivity of Solvent Extract.** The resistivity of the solvent extract shall have a final value greater than 2,000,000 ohm-cm.
2. **Sodium Chloride Salt Ionic Contamination Equivalent Test.** The final value for this test must be less than 10 micrograms per square inch of PWB surface area.

3A1104 RESISTIVITY OF SOLVENT EXTRACT

Solvent extract resistivity shall be measured as follows (also, see Table 11-1):

1. Prepare a test solution of 75 percent by volume isopropyl alcohol and 25 percent by volume deionized water. Pass this solution through a mixed bed deionizer cartridge. After passage through the cartridge, the resistivity of the solution shall be greater than 6×10^6 ohm-cm (conductivity less than 0.166 micromhos/cm).
2. Clean a funnel, a wash bottle, and a container with a portion of this test solution. Measure out 10 milliliters of fresh test solution for each square inch of assembly area on both sides of the PWA.
3. Slowly, direct the test solution in a fine stream onto both sides of the PWA until all the measured solution is used.
4. The resistivity of the solvent extract shall be determined using a resistivity meter.

3A1105 SODIUM CHLORIDE SALT EQUIVALENT IONIC CONTAMINATION TEST

Sodium chloride salt equivalent ionic contamination shall be measured as follows (also, see Table 11-1):

1. The sodium chloride salt equivalent ionic contamination test must use a solution of 75 percent isopropyl alcohol and 25 percent deionized water. This solution must be verified for correct composition upon initial use and every 4 hours during a shift. The time limit may be extended when the results of data provide definite indications that such actions will not adversely affect the results of the test.

2. The equipment must be calibrated using a known amount of sodium chloride standard on the same schedule as the percentage composition verification.
3. The starting or reference purity of the solution must be greater than 20×10^6 ohm-centimeters (0.05 micromhos/centimeter) before each sample is tested.
4. Commercial equipment is available that can perform this test automatically. Such equipment is recommended for the control of continuous solvent cleaning operations. The equipment gives a direct readout in micrograms of NaCl per square inch (or square centimeter), but requires careful calibration to the flux system used, for accurate results.

TABLE 11-1. Cleanliness Test Values

Test Method	Starting Resistivity	Ending Value
Solvent Extract Resistivity	6×10^6 ohm-cm	Shall be greater than 2×10^6 ohm-cm
Sodium Chloride Salt Equivalent Ionic Contamination	20×10^6 ohm-cm	Shall be less than 10.0 micrograms/square inch

CHAPTER 12: VERIFICATION

3A1200 GENERAL

When prescribed by the procuring NASA Installation, verification tests shall be conducted to establish confidence in the reliability of the solder joints. A test plan shall be submitted to the procuring NASA Installation or its designated representative for approval. The test plan shall detail the test environment, test duration, test assembly design, and failure criteria, based on life and mission requirements.

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APPENDIX A

DEFINITIONS

The following definitions apply to terms used in this handbook.

Article. A unit of hardware or any portion thereof required by the contract.

Assembly. A functional subdivision of a component, consisting of parts or subassemblies that perform functions necessary for the operation of the component as a whole. Examples: regulator assembly, power amplifier assembly, gyro assembly, etc.

Axial lead. Lead wire extending from a component or module body along its longitudinal axis.

Bifurcated (split) Terminal. A terminal with a slot or split opening in which conductors are placed before soldering.

Birdcage. A defect in stranded wire where the strands in the stripped portion between the covering of an insulated conductor and a soldered connection (or an end-tinned lead) have separated from the normal lay of the strands.

Blister. Raised areas on the surface of the laminate caused by the pressure of volatile substances entrapped within the laminate.

Blow Hole. A cavity in the solder surface whose opening has an irregular and jagged form, without a smooth surface.

Bridging. A buildup of solder between components, conductors, and/or base substrate forming an undesired conductive path.

Certification. The act of verifying and documenting that personnel have completed required training and have demonstrated specified proficiency and have met other specified requirements.

Circumferential Separation. A crack or void in the plating extending around the entire circumference of a PTH, or in the solder fillet around the conductor, in the solder fillet around an eyelet, or at the interface between a solder fillet and a land.

Cold Flow. Movement of insulation (e.g., Teflon) caused by pressure.

Cold Solder Connection. A solder connection exhibiting poor wetting and a grayish, porous appearance due to insufficient heat, inadequate cleaning before soldering, or excessive impurities in the solder.

Component. A functional subdivision of a system, generally a self-contained combination of assemblies performing a function necessary for the system's operation. Examples: power supply, transmitter, gyro package, etc.

Conduction Soldering. Method of soldering which employs a soldering iron for transfer of heat to the soldering area.

Conductor. A lead, solid or stranded, or printed wiring path serving as an electrical connection.

Conformal Coating. A thin electrically nonconductive protective coating that conforms to the configuration of the covered assembly.

Connection. An electrical termination that was soldered. A solder joint.

Contaminant. An impurity or foreign substance present in a material that affects one or more properties of the material. A contaminant may be either ionic or nonionic. An ionic, or polar compound, forms free ions when dissolved in water, making the water a more conductive path. A non-ionic substance does not form free ions, nor increase the water's conductivity. Ionic contaminants are usually processing residue such as flux activators, finger prints, and etching or plating salts.

Contractor. The individual(s) or concern(s) who enter into a prime contract with the Government.

Crazing. An internal condition occurring in the laminate base material in which the glass fibers are separated from the resin.

Cup Terminal. A hollow, cylindrical terminal to accommodate one or more conductors.

Delamination. A separation between plies within a base material, between a base material and a conductive foil, or any planar separation within a multilayer PWB.

Deviation. A specific authorization, granted before the fact, to depart from a particular requirement of specifications or related documents.

Dewetting. The condition in a soldered area in which the liquid solder has not adhered intimately, but has receded, characterized by an abrupt boundary between solder and conductor, or solder and terminal/termination area leaving irregularly shaped mounds of solder separated by areas covered with a thin solder film.

Disturbed Solder Joint. Unsatisfactory connection resulting from relative motion between the conductor and termination during solidification of the solder.

Dross. Oxide and other contaminants that form on the surface of molten solder.

Egress. An opening that provides a pathway from the interior of an enclosed space.

Encapsulating Compound. An electrically nonconductive compound used to completely enclose and fill in voids between electrical components or parts.

Excessive Solder Joint. Unsatisfactory solder connection wherein the solder obscures the configuration of the connection.

Eyelet. A hollow tube inserted in a terminal or PWB to provide mechanical support for component leads or for electrical connection.

Flatpack. A part with two straight rows of leads (normally on 0.050 inch centers) that are parallel to the part body.

Fillet. A smooth concave buildup of material between two surfaces; e.g., a fillet of solder between a conductor and a solder pad or terminal.

Flux. A chemically-active compound which, when heated, removes minor surface oxidation, minimizes oxidation of the basis metal, and promotes the formation of an intermetallic layer between solder and basis metal.

Fractured Solder Joint. A joint showing evidence of cracking, resulting from movement between the conductor and termination, after solidification of the solder.

Haloing. Mechanically-induced fracturing or delaminating on or below the surface of the base PWB material; it is usually exhibited by a light area around holes, other machined areas, or both.

Hook Terminal. A terminal formed in a hook shape.

Insufficient Solder Connection. A solder connection characterized by incomplete coverage of one or more of the metal surfaces being joined or by incomplete solder fillets.

Interfacial Connection. A conductor that connects conductive patterns between opposite sides of a PWB.

Interlayer Connection. An electrical connection between conductive patterns in different layers of a PWB.

Joint. A solder joint; a termination.

Lifted Land. A land that has lifted or separated from the base material, whether or not any resin is lifted with the land.

Measling. Discrete white spots below the surface of the base material, usually caused by moisture, pressure, and/or thermally induced stress.

Mission Essential Support Equipment. Equipment used in a closed loop with the system, where failure of this equipment would degrade the mission or imperil personnel. This category includes items of ground support equipment whose functions are necessary to support the count down phase and those items of ground support equipment used in pre-count down phases whose problems can create a safety hazard, cause damage to flight hardware, or inability to detect a problem on the flight hardware.

Nick. A cut or notch on a conductor.

Nonwetting. A condition whereby a surface has contacted molten solder, but the solder has not adhered to all of the surface; basis metal remains exposed.

Outgassing. Gaseous emission from a PWA when exposed to a reduced pressure, heat, or both.

Overheated Joint. An unsatisfactory solder joint, characterized by rough solder surface; dull, chalky, grainy, porous or pitted.

Pad. A portion of a conductive pattern used as a soldering area. Also termed land.

Part. An element of a component, assembly, or subassembly that is not normally subject to further subdivision or disassembly without destruction of designed use.

Part Lead. The solid conductor attached to a part.

Pierced (Perforated) Terminal. A terminal containing a hole through which conductors are placed before soldering.

Pinhole. A solder connection with a small hole penetrating from the surface of the solder to a void of indeterminate size within the solder connection.

Pit. A relatively small recess in the solder surface, the bottom of which is visible from all angles of vision.

Plated-Through Hole (PTH). A plated-through hole is one formed by a deposition of metal on the inside surface of a through-hole. Also known as a supported hole. The configuration is used to provide additional mechanical strength to the soldered termination or to provide an electrical interconnection on a multilayer PWB.

Porous Solder Joint. A joint having a grainy or gritty surface.

Potting Compound. An electrically nonconductive compound used to partially encapsulate or for a filler between parts, conductors, or assemblies.

Printed Wiring Assembly (PWA). The PWA consists of the PWB, components, and associated hardware and materials.

Printed Wiring Board (PWB). A pattern of conductors printed (screened) onto the surface of an insulating base to provide interconnection for parts.

PTH. Plated-through hole.

PWB. Printed wiring board.

Radial Lead. Lead wire extending from a component or module body along its latitudinal axis.

Radial Split. A crack or other separation in the flange of an eyelet or other circular connector, which extends outward from the center. Such cracking is usually the result of swaging or other setting process as the item is embraced in a printed wiring board.

Repair. Operations performed on a nonconforming article to place it in usable condition. Repair is distinguished from rework in that alternate processes rather than reprocessing are employed.

Resistance Soldering. Method of soldering by passing a current between two electrodes through the area to be soldered.

Rework. The reprocessing of articles or material that will make it conform to drawings, specifications, and contract.

Rosin Solder Joint. Unsatisfactory connection that has entrapped rosin flux. This entrapment is usually due to insufficient heat or insufficient time at soldering temperature, or both, not enabling the rosin to rise to the surface of the solder. This results in insufficient bonding and/or high electrical resistance.

Solder. A nonferrous, fusible metallic alloy used to join metallic surfaces.

Solderability. The property of a surface that allows it to be wetted by a molten solder.

Solder Connection. An electrical/mechanical connection that employs solder for the joining of two or more metal surfaces.

Soldering. The process of joining clean metallic surfaces through the use of solder without direct fusion of the base metals.

Solder Mask. Coating material used to mask or protect selected areas of a pattern from the action of an etchant, solder, or plating.

Solder Pad. Termination area on a printed wiring conductor.

Solder Spatter. Extraneous irregular-shape solder fragments.

Solder Spike. A cone shaped peak or sharp point of solder usually formed by the premature cooling and solidification of solder on removal of the heat source.

Staking Compound. An electrically nonconductive adhesive material used for additional support after a component has been attached by mechanical or soldering process.

Straight-Pin Terminal. A round post-type smooth terminal, with no grooves.

Straight-Through Termination. A conductor termination extending through a PWB without subsequent forming of the lead.

Stress Relief. The formed portion of a conductor that provides sufficient length to minimize stress between terminations.

Stud Termination. An unbendable conductor termination extending through a PWB.

Subcontractor. The individual(s) or concern(s) who enter into a purchase agreement under a Government prime contract.

Supplier. In-house NASA, NASA contractors, and subtier contractors.

Supportive Hole. A hole in a printed board that has its inside surface plated or otherwise reinforced.

Surface Mounting. The electrical connection of components to the surface of a conductive pattern that does not utilize part holes.

Terminal. A tie point device used for making electrical connection.

Termination. The point at which electrical conductors are joined.

Termination Area. A conductive surface on a PWB used for making electrical connections (also referred to as a solder pad).

Thermal Shunt. A device with good heat dissipation characteristics used to conduct heat away from an article being soldered.

Tinning. The coating of a surface with a uniform layer of solder.

Tubelet. A tubular metal part. Its ends may or may not be flared.

Turret Terminal. A round post-type grooved stud around which conductors are fastened before soldering.

Unsupported Hole. A hole containing no plating or other type of conductive reinforcement.

Via. A PTH used as an interlayer connection, but in which there is no intention to insert a component or other reinforcing material.

Void. A space enclosed on all sides by the solder.

Waiver. Granted use, or acceptance, of an article that does not meet specified requirements.

Wave Soldering. A process wherein PWA's are brought in contact with the surface of continuously flowing and circulating solder.

Wetting. Flow and adhesion of a liquid to a solid surface, characterized by smooth, even edges, and a low dihedral angle.

Wicking. A flow of molten solder or cleaning solution by capillary action.



APPENDIX B

TYPICAL ACCEPTABLE SOLDER CONNECTIONS

The illustrations in this appendix depict acceptable maximum and minimum amounts of solder on typical solder connections. Accept - reject criteria can be found in Chapter 10.

TYPICAL ACCEPTABLE SOLDER CONNECTIONS

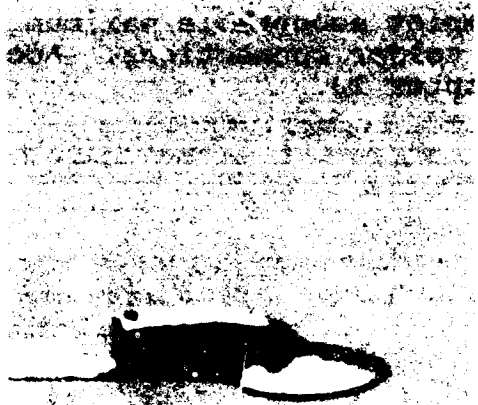


FIGURE 1

THIS TYPE OF SOLDER JOINT IS
THE DESIRED TYPE AND SHOULD BE
USED IN ALL SOLDERING WORK



FIGURE 2



FIGURE 3



FIGURE 4

TYPICAL ACCEPTABLE SOLDER CONNECTIONS	
<p>FIGURE 1</p> <p>PWB clinched termination: Round lead.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 2</p> <p>PWB clinched termination: Round lead.</p> <p>MAXIMUM ACCEPTABLE</p>
<p>FIGURE 3</p> <p>PWB stud Termination.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 4</p> <p>PWB stud termination.</p> <p>MAXIMUM ACCEPTABLE</p>

TYPICAL ACCEPTABLE SOLDER CONNECTIONS



FIGURE 5



FIGURE 6



FIGURE 7

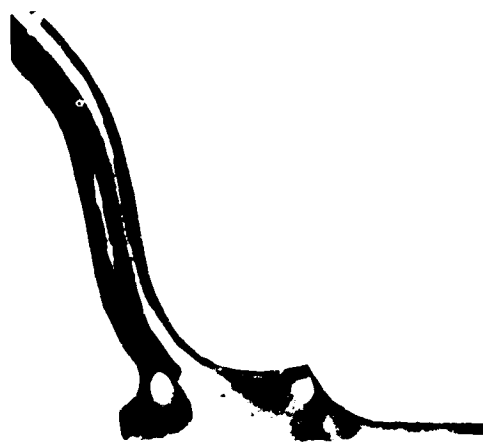


FIGURE 8

TYPICAL ACCEPTABLE SOLDER CONNECTIONS	
<p>FIGURE 5</p> <p>PWB lapped termination: Round lead through the PWB.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 6</p> <p>PWB lapped termination: Round lead through the PWB.</p> <p>MAXIMUM ACCEPTABLE</p>
<p>FIGURE 7</p> <p>PWB lapped termination: Round lead from same side of PWB.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 8</p> <p>PWB lapped termination: Round lead from same side of PWB.</p> <p>MAXIMUM ACCEPTABLE</p>

TYPICAL ACCEPTABLE SOLDER CONNECTIONS



FIGURE 9



FIGURE 10



FIGURE 11



FIGURE 12

TYPICAL ACCEPTABLE SOLDER CONNECTIONS	
<p>FIGURE 9</p> <p>PWB lapped termination: Ribbon lead through the PWB.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 10</p> <p>PWB lapped termination: Ribbon lead through the PWB.</p> <p>MAXIMUM ACCEPTABLE</p>
<p>FIGURE 11</p> <p>PWB lapped termination: Ribbon lead from the same side of the PWB.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 12</p> <p>PWB lapped termination: Ribbon lead from the same side of the PWB</p> <p>MAXIMUM ACCEPTABLE</p>

TYPICAL ACCEPTABLE SOLDER CONNECTIONS

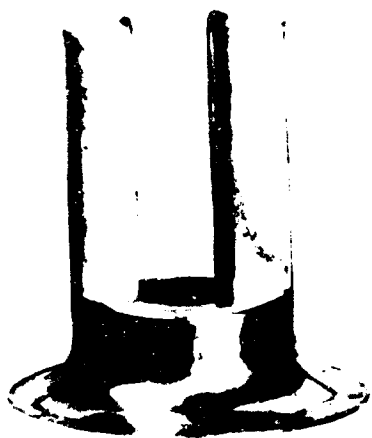


FIGURE 13



FIGURE 14



FIGURE 15



FIGURE 16

TYPICAL ACCEPTABLE SOLDER CONNECTIONS	
<p>FIGURE 13</p> <p>PWB terminal mounting: Soldering of bifurcated terminal to pad.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 14</p> <p>PWB terminal mounting: Soldering of bifurcated terminal to pad.</p> <p>MAXIMUM ACCEPTABLE</p>
<p>FIGURE 15</p> <p>PWB terminal mounting: Soldering of "V" funnel swage.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 16</p> <p>PWB terminal mounting: Soldering of "V" funnel swage.</p> <p>MAXIMUM ACCEPTABLE</p>

TYPICAL ACCEPTABLE SOLDER CONNECTIONS

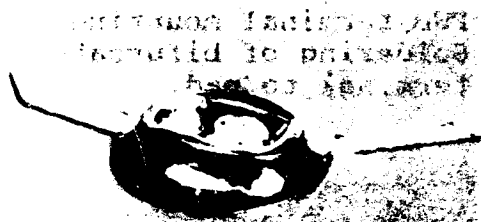


FIGURE 17



FIGURE 18



FIGURE 19



FIGURE 20

TYPICAL ACCEPTABLE SOLDER CONNECTIONS	
<p>FIGURE 17</p> <p>PWB terminal mounting: Soldering of Elliptical swage.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 18</p> <p>PWB terminal mounting: Soldering of Elliptical swage.</p> <p>MAXIMUM ACCEPTABLE</p>
<p>FIGURE 19</p> <p>Cup terminal termination: Connector pin type.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 20</p> <p>Cup terminal termination: Connector pin type.</p> <p>MAXIMUM ACCEPTABLE</p>

TYPICAL ACCEPTABLE SOLDER CONNECTIONS

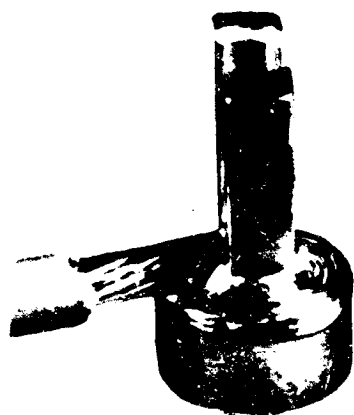


FIGURE 21



FIGURE 22

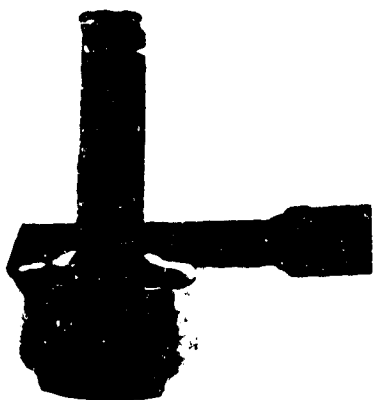


FIGURE 23

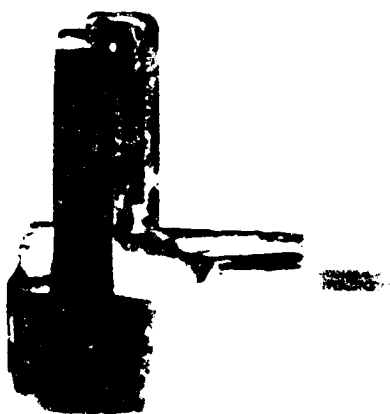


FIGURE 24

TYPICAL ACCEPTABLE SOLDER CONNECTIONS	
<p>FIGURE 21</p> <p>Bifurcated terminal termination: Single wire.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 22</p> <p>Bifurcated terminal termination: Single wire.</p> <p>MAXIMUM ACCEPTABLE</p>
<p>FIGURE 23</p> <p>Bifuracted terminal termination: Straight through.</p> <p>MINIMUM ACCPETABLE</p>	<p>FIGURE 24</p> <p>Bifurcated terminal termination: Straight through.</p> <p>MAXIMUM ACCEPTABLE</p>

TYPICAL ACCEPTABLE SOLDER CONNECTIONS



FIGURE 25

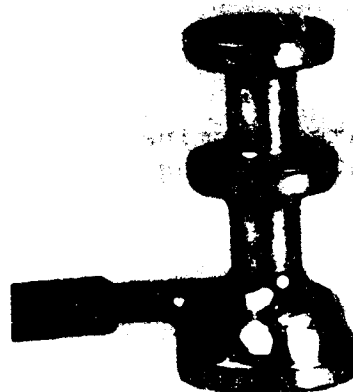


FIGURE 26



FIGURE 27



FIGURE 28

TYPICAL ACCEPTABLE SOLDER CONNECTIONS

FIGURE 25

Turret terminal
termination: Single
wire.

MINIMUM ACCPETABLE

FIGURE 26

Turret terminal
termination: Single
wire.

MAXIMUM ACCEPTABLE

FIGURE 27

Hook terminal
termination: Single
wire.

MINIMUM ACCPETABLE

FIGURE 28

Hook terminal
termination: Single
wire.

MAXIMUM ACCEPTABLE

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